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An act, known as the Kaufmann Act, was recently passed by the New York state legislature which requires all railroads within the New York City limits to be electrified by January 1, 1926. This act imposes obviously impossible conditions upon the railroads effected. The Baltimore & Ohio has indicated its intention to meet the requirements of the act, practically without argument, by announcing its decision to electrify its lines on Staten Island beginning with the line from St. George to Tottenville and South Beach.

The Baltimore & Ohio Electrification

This prompt decision is significant for several reasons. It indicates the willingness of the Baltimore & Ohio to comply with public demand, it registers assurance in the desirability of electric traction for service of this kind, and reflects the improved financial condition of the road and its faith in the future. The cost of electrifying the line from St. George to Tottenville and South Beach calls for an expenditure of $6,000,000 and if all of the Baltimore & Ohio lines on Staten Island are electrified the cost will probably approximate $15,000,000. Major improvements of this kind can only be made when a railroad is in a sound financial condition and when the management is convinced that the investment will be a profitable one.

The lighting of classification yards has recently aroused considerable interest. The illumination of such places is without doubt one of the most difficult of lighting problems. The necessity for efficient night operation is daily becoming more urgent, and with proper lighting facilities there is no reason why night work in classification yards should not be carried on with almost, if not quite, the same degree of efficiency as in daylight. It is true that there is still considerable diversity of opinion as to the most efficient method of yard lighting, yet evidence is not lacking to show that the subject is receiving the best efforts on the part of both manufacturers of lighting units and of railroad men.

Development of Yard Lighting

Indications are that the same type of lighting will not be suitable for all kinds of yards and opinions differ widely as to just what the best method is. As a matter of fact, the best method for one location may not be the best for another, and it is these varied conditions that bring about differences of opinion. Some yards have been laid out wholly with flood lighting equipment and appear to give entire satisfaction. On the other hand, some roads seem to be very much opposed to flood lighting, claiming that it produces glare. Silhouette lighting in some quarters appears to be looked upon with considerable favor. The truth is there is such a variety of factors to be considered in planning yard lighting that in reality the matter resembles a complicated mathematical problem in which there are too many unknown quantities to arrive at an exact solution. The need for adequate lighting in yards is pressing and it is highly probable that lighting systems will be developed in the not distant future which will give satisfaction and will meet all the requirements of yards of every kind.

The year 1924 bids fair to be one of much activity in railroad circles so far as the work of electrical engineers is concerned. The outstanding feature of the electrical program on many roads is bound to be the installation of train control equipment in compliance with the requirements of the Interstate Commerce Commission. Even though the requirements call for the equipment of but one division of each of the 49 larger roads, this will be sufficient to give the electrical men much to think about during the next 12 months. It is not probable that the time for this installation will be extended beyond that fixed by the commission and this means that the year 1924 is certain to be one of feverish activity along the lines of adoption and installation of train control apparatus and the solution of the more or less complex problem of maintenance.

The Train Control Outlook

A number of train control systems have been developed and are being tried out. Once a system has been adopted, the problem of installation becomes one of routine work. The installation probably will not cause any particular difficulty, but the question of maintaining this apparatus after it has been placed in service is something to which the most careful attention will have to be given if it is to function as intended. In other words, while the selection and installation are important in themselves, the most important problem is that of maintaining these new appliances after they have been installed.

The mere fact that the work of looking after the equipment must be undertaken by three separate departments, namely, the signal, the mechanical and the electrical, is almost certain to bring about new and perplexing questions as to the responsibility of each department. This will be emphasized in the event of the failure of the apparatus to function during its regular operation. There will be a strong incentive to shift the blame of any failure from one department to another unless some steps are taken to put the supervision of the train control equipment under an

authoritative head. At present it seems difficult to see just how this co-ordination of the three departments will be brought about but the necessity for it is apparent and to just the extent that this effort is successful will the maintenance of train control equipment be satisfactory. The problem will be eventually solved but it undoubtedly will come in for its share of attention during the coming year.

Prospects for Electric Traction

Progress in the adoption of electric traction on steam railroads, suspended during the war and subsequently because of post-war conditions, has apparently been resumed. Much progress was made during the year 1923. The Virginian reached a decision to electrify 134 miles of line and contracts totaling $15,000,000 have been let for this purpose. Work of electrifying the Detroit & Ironton has been started and about $1,000,000 worth of equipment has been ordered for the electrification of 13¼ miles of line. This is apparently only the first step in the consummation of a much more extensive plan. The recent decision of the Baltimore & Ohio to electrify its lines on Staten Island is announced elsewhere in this issue. This will involve an expenditure of from $6,000,000 to $15,000,000. Work on the Illinois Central electrification is in progress.

Roads already operating electrified sections in this country have purchased additional locomotives. This includes 12 locomotives for the New Haven, 2 for the Baltimore & Ohio, 4 for the Norfolk & Western and 3 for the Pennsylvania. These activities indicate that the managements are convinced of the desirability of using electric motive power under favorable conditions and are also an indication of the generally improved financial condition of the railroads.

The two large electrical manufacturing companies are apparently willing to bury the hatchet in the a. c.-d. c. controversy and if railroad activities are not stultified by adverse legislation, 1924 should be a greater year than 1923 for electric traction development. Federal legislators may make a political football of the Transportation Act during the coming campaign, but the chances are good that the bloc methods in Congress will result in preventing the passage of much legislation affecting the railroads either favorably or adversely. With this assurance, it seems safe to say that the condition of arrested development in electric traction activities may be considered a thing of the past.

Electric Arc Welding

Among other developments of much concern to electrical engineers in the months to come is that of electric welding. As in the past, it will probably be left to the electrical engineer to champion the cause of electric welding and see that it is used where it should be used. The art of welding has been slowly but surely increasing in favor and the number of applications where it can be successfully and economically applied appear to be almost without limit. At present, as in the past, its greatest usefulness is found in its adaptability to the reclamation of worn or broken parts. There is, however, an ever-increasing tendency to use welding for construction work. This may mean the building of a pulley wheel from sheet metal, putting together odd shapes as in car seat frames, the manufacture of tanks, or the fabrication of structural steel in building construction. Welding in construction, too, has proved an incentive to ingenious minds. Instead of always using new material the scrap pile has been called upon for the manufacture of equipment, such as building poles from scrap rail. It is in this direction that welding will probably find its greatest increase of usefulness. In this connection, it is important to consider recent developments in spot welding, resistance welding and automatic electric arc welding machines.

The electric welding process is by no means confined to ferrous metals. It has been successfully used in welding copper to steel without deleterious effect upon the characteristics of the steel. This suggests possibilities in the welding of bonds which have not as yet been realized. One of the most important factors in the consideration of electric welding is the economy which attends its use and with this feature, railroads must ever be concerned. There is little question but that 1924 will see a very substantial increase in the number of electric welding equipments used on steam railroads.

Suburban Coach Lighting

Problems of suburban coach lighting are often most perplexing; the conditions of this type of service differ so widely from that of the long runs that the requirements frequently have to be met in quite a different manner from that used on through trains. Moreover, the suburban coach lighting problem on different roads may not be the same. In suburban service, where stops are frequent, batteries do not always get the amount of charging that they should, although this difficulty has been overcome successfully on some roads by adjusting the regulator devices so that the cut-in switches operate at lower speeds.

On a number of roads head-end lighting systems have been installed and appear to give entire satisfaction. There can be no question but that head-end lighting, with the turbo-generator located on the locomotive, requires less attention than the more common axle lighting system, provided it is practical to adopt a head-end system, but it must be remembered that the train operation where head-end equipment is used is of a special nature and will not be suitable where cars must be used in a variety of services. For the simplicity of maintenance, much can be said for the turbo-generator lighting, though, on the other hand, its simplicity is secured at the cost of inflexibility of equipment. Trains using the turbo-generator systems must always be operated as a unit, since no provision is made on any of the cars for storage battery lighting. If conditions are such that it is possible always to operate certain cars on certain trains each day then head-end lighting may be looked upon with favor, but unless this condition is obtainable, the installation of such a system is not practicable.

Small axle lighting equipments can be obtained which will perhaps be more suitable for certain classes of suburban service. In considering the relative merits of the two methods, too much thought cannot be given to the subject, and the ultimate decision should only be arrived at after every factor has been most carefully weighed.

A Group of Pullman Electricians, Sunnyside Yards, Pennsylvania Railroad, New York

How A Car Lighting Man's Time Is Divided

Analysis of Maintenance Work in Large Terminal Yard Throws Light Upon a Most Important Problem

By C. E. Foutz

EVERY foreman-electrician, electrical supervisor or inspector, at some time or other, is confronted with the disagreeable task of explaining to the superintendent or another official why it takes so-and-so many men to run a yard. All kinds of figures are given, so many minutes here, and so many minutes per car there, until after it is all estimated he usually finds that everybody questions his figures and it all has to be done over again. Then, too, resultant changes having to bear the approval of an official who usually is not familiar with the details of the work, tend to create more arguments and it seems an almost endless job.

The factors that govern these changes are many and variable. For instance, the steady application of new and more up to date equipment, both for replacing discarded equipments and on new cars, is of great importance toward reducing the amount of time allowed for yard repairs; the almost impossible task of trying to keep the ranks filled with well trained and skilled employees constantly affects the length of time required to perform different classes of repairs and, the flood of green men such as occurred during the war and following the labor strike in 1922 makes it a seemingly endless task of breaking in new men and building up organizations. This, together with many other similar conditions requires a constant changing of organizations employed in this work in order to operate most efficiently.

To arrive at some definite figure regarding a car-lighting man's time, the Pullman company undertook to analyze this feature of its maintaince work in one of its largest yards—the Sunnyside yards of the Pennsylvania Railroad in Long Island City, New York—just prior to the labor strike previously referred to. At this time and at this place conditions were nearest to the ideal and most favorable for determining an average figure applicable to the larger class of yards.

The task was accomplished only after an exhaustive effort to conduct an eight day check on the working time of each employee engaged in this work. From the data collected, averages were computed on the several bases as will be seen later.

It will be necessary, however, to give a brief description of this yard and its organization to aid the reader in understanding more clearly the results.

This organization consists of, nine machine men whose duties are confined to the daily running repairs and inspection of the axle generators, suspensions, axle pulleys, belts and regulators; six inside men who give the same attention to the interior wiring and fixtures of the electric lighting and call bell systems of the cars; two incoming testers who make a voltage test on all cars upon their arrival in the yard; two station duty men who make an outgoing inspection of all cars departing from the Penna. station; two special duty men who act as gang-leaders in the yard; two shop men who make the repairs to parts taken to the shop for that purpose; nine overhauling men who make the periodical overhaulings of the equipments and seven battery men who exchange, repair and flush batteries periodically, making a total of thirty-nine employees in the organization. This excludes, however, three relief men and two laborers whose time does not affect the total for the main organization. The unit is

entirely supervised by one assistant general yard foreman.

This unit, with the exception of armature winding and battery washing, handles the entire maintainance of the carlighting equipment on all Pullman cars operated out of this district.

During the test the average daily departures of cars from the yards were approximately 280 axle lighted cars. At present this figure is approximately 310 cars daily.

The main yard, being one of the most up to date yards of its size, consists of forty storage tracks with a total normal capacity of 475 cars. Were all of these tracks filled to their normal capacity one would be required to walk 1.18 miles to start from the yard building at one corner and walk completely around the group of cars proper.

It is hoped that this information will furnish to the reader an idea of the amount of time consumed by the employees in going to and from cars located in various parts of the yard and on which their actual work is done.

The total time consumption is divided under the following headings. "Common loss" including 20 minutes for lunch, 5 minutes checking in and out at the change of shifts and 5 minutes to and from the cars in the yard (4 times daily). "Allowance between trains" representing the time consumed in passing from one train to another. "Storeroom trips" representing the time consumed in going to and from the storeroom after material (10 minutes per trip), "At storeroom" the time consumed in waiting at the storeroom for material. "Blue flags" that time required for the placing and removal of blue flags, especially applicable to machine men, approximately 8 minutes per train. "Unaccounted for" represents that time consumed other than on the cars and for which no special provision has been made. "Time on cars" representing the time actually consumed in repair work on the cars proper. "Total" is the total for all positions.

The following table contains the figures on the items described above and represents averages compiled from the individual checkings and observations made on each employee.

	Machine men	Inside men	Incoming testers	Station duty	Special duty	Shop	Overhauling	Battery work	Total	Per cent
Positions	9	6	2	2	2	1	2	3	27	
Employees	9	6	2	2	2	2	9	7	39	
Common loss	50	50	50	40	50	40	50	50	380	
Between trains	40	50	204	187	95	..	..	45	621	
Storeroom trips	30	20	..	20	10	..	15	10	105	
At storeroom	13	12	..	..	6	..	11	10	52	
Blue flags	67	..	..	..	..	..	..	..	67	
Unaccounted for	..	34	..	..	35	..	43	4	116	
Total	200	166	254	247	196	40	119	119	1,341	35%
Per cent loss	41	34	52	51	40	8	24	24	...	
Time on cars	280	314	226	233	284	440	360	361	2,499	65%

On a per man per day basis we have

Trains	8	10	26	37	19
Cars	31	44	126	140	95
Trips to storeroom	3	2	..	4	1
Time per car	8.86	7	1.7	1.6	2.6

Note—All computations are made in minutes per man per day.

To simplify the figures decimals have been omitted.

Computing the same data on a basis of comparison between the total amount of time actually consumed on the cars and that consumed otherwise, for the respective positions we find the following:

Distribution	On cars	Other than on cars
Nine machine men	2,520	1,800
Six inside men	1,884	996
Two incoming testers	452	508
Two station duty men	466	494
Two special duty men	568	392
Two shop men	880	80
Nine overhauling men	3,249	1,071
Seven battery men	2,527	833
Total	12,546—(209.1 hrs.)	6,174—(102.9 hrs.)
Per cent	67%	33%

The foregoing represents the distribution of the total hours (312) for the entire unit of 39 employees, eight hours per day per man.

Of these results the first twenty-one employees represent the amount of time consumed in making the daily running repairs to the equipments and is chargeable against "electric lighting accounts." The time of the remaining 18 employees represents that consumed in making the periodical inspections and repairs such as overhauling, battery flushing, etc., and which is charged against "car accounts."

	Electric lighting account		Car account	
Distribution				
Nine machine men	2,520	1,800	....	....
Six inside men	1,884	996	....	....
Two incoming testers	452	508	....	....
Two station duty men	466	494	....	....
Two special duty men	568	392	....	....
Two shop men	....	....	880	80
Nine overhauling men	....	....	3,249	1,071
Seven battery men	....	....	2,527	833
Total	5,890	4,190	6,656	1,984
Per cent	31.5%	22.4%	35.5%	10.6%

One of the most interesting features of this test is to learn just how much time per day each car receives in the maintenance of daily running repairs. This is shown in the following:

Distribution	On car	Other than on car	Total	
Machine men	8.86	6.35	15.21	
Inside men	7.	3.78	10.78	
Incoming testers	1.78	2.02	3.80	
Station	1.66	1.74	3.4	
Special duty	2.6	2.06	4.66	
Total	21.90	15.95	37.85	37.85
(These figures are computed on an allowance of total time per car per day basis. On an average of 280 cars per day):				
Shop			3.53	
Overhauling			15.4	
Battery			11.97	
Total minutes per day for periodical maintenance work			30.90	30.90
Total minutes per car per day			....	68.75

To further furnish the reader with a clearer conception of the amount of work accomplished on the foregoing basis of time distribution some of the principal items of repairs made during the year of 1921 will be given.

These are as follows: 2,120 cases of battery trouble repaired; 1,932 equipments overhauled; 4,111 batteries flushed; 3,640 cars charged in the yard 309 sets of batteries exchanged; 590 armatures exchanged (excluding overhaulings); 372 armatures repaired locally; 4,285 generator belts applied; 45,215 burnt out lamps renewed.

These observations were taken of the organization exactly as it was functioning at that time to insure true results, as near as possible.

No attempt will be made to draw any definite conclusions from the foregoing in so far as it was intended to be used as a foundation upon which future improvements could be made. There are, however, a number of interesting features in connection with the test, the principal ones being the amount of time spent other than on the cars; the amount of time that each car receives daily; general scope of the repair work carried on and how the total time is distributed, and it is hoped that many improvements can be made in the future.

Locomotive Passing Over Clear Ramp

Train Control in Service on the Rock Island

First Installation to Be Officially Inspected by the I. C. C. Under the Order

THE Chicago, Rock Island & Pacific, in compliance with the Interstate Commerce Commission's Order No. 13,413, has installed automatic train control on 165 miles of its double track main line between Blue Island (Chicago), Ill., and Rock Island. The automatic train control system of the Regan Safety Devices Company, Inc., as used on this installation, is the intermittent ramp contact type, with speed control. The roadside equipment consisting of the ramp and circuits connecting the train control and automatic (visual) signal system, was completed on November 1. There are 89 road engines assigned regularly to the Illinois division, of which 38 are for passenger and the rest for freight service.

An official inspection of this train control installation was made by W. H. Harland, chief of the division of signals and train control of the I. C. C., and his staff, during the latter part of November and it was pronounced complete and in full compliance with the requirements of the commission, as was announced by the railroad on December 4. Therefore, the Rock Island is the first road to receive an official inspection and approval of an automatic train control installation on a full engine district, as specified in the order.

Record of Tests Made

The inspection and test of the roadside apparatus was made by parties, each consisting of two inspectors of the Interstate Commerce Commission, accompanied by representatives from the Rock Island and the Regan Company. One of these parties started from Blue Island on November 19, and one from Rock Island on November 20. The inspection and test at each location consisted of measurements of gage and height of ramps, check of potential and polarity, and a general examination of the construction at each location. A check was also made of switch protection, overlaps, grade, etc. All ramp locations throughout the installation were examined in detail by the government inspectors.

An inspection and test was made of each equipped locomotive to determine the integrity of the apparatus, including operation under the several conditions of train control, such as unlimited speed, limited speed and stop, with tests of the integrity of the circuits, grounds, elevation and gage of shoe mechanism, etc., including the seals applied to the air cocks. These tests were also to determine whether the installation was made in accordance with the plans. Observations of the automatic train control apparatus in regular train service were made, with a record of date, engine number, train number, signal indications, speed of train, reduction in pounds of brake pipe pressure, and whether the apparatus operated as intended.

At the request of the Interstate Commerce Commission a special train was run from Blue Island on November 30, for the purpose of demonstrating the flexibility of the system. The train consisted of engine 1328 with five cars, including a business car which was fitted with a speed recorder and train-line gages. Tests were made at unlimited speed, at prescribed medium speed and at stop, corresponding to the signal indications—Proceed Proceed with Caution, and Stop. The purpose of these tests was to demonstrate that the apparatus operated as intended and at the prescribed speeds at which it was set. On the return trip the train was operated with the locomotive running backwards and the various indications were received the same as when the locomotive was running forward.

Territory Included and Traffic Handled

Blue Island, Ill., is 15.7 miles from the La Salle street station, Chicago, and is considered as the end of the

Chicago terminal district, as the majority of the suburban trains from the city terminate at Blue Island. The passenger traffic on the Illinois division is broken up at Joliet, which is 24.5 miles west of Blue Island and at Bureau, Ill., which is 98 miles west of Blue Island. In addition to the through trains there are eight suburban trains each way between Joliet and Chicago. Bureau is the junction with a branch to Peoria, Ill., and three passenger trains each way are run between this point and Chicago. Therefore a summary of the passenger train movements is as follows: Blue Island to Joliet, 18 passenger trains each way, Joliet to Bureau 10 passenger trains each way, Bureau to Rock Island, 7 passenger trains each way. The Rocky Mountain Limited, train No. 7, westbound, traverses the 165 miles of train control territory in 3 hr. 40 min., at an average scheduled speed of 43.5 m.p.h. One of the Joliet suburban trains runs at an average speed of 40.2 m.p.h.

For the six months' period from June to November, 1923, inclusive, there was an average of 13 eastbound and 12 westbound freight trains on the Illinois division for each 24-hr. period. The freight train speeds average between 13.1 m.p.h. and 17 m.p.h. The ruling grade of 0.62 per cent for approximately six miles east of Joliet limits the eastbound tonnage of the larger freight engines to 3,370 tons as an adjusted rating between Morris, Ill., and Blue Island. At Tiskilwa, nine miles west of Bureau, the line leaves the Illinois river valley and climbs 154 ft. within a distance of 14 miles, with a maximum westbound grade of 0.6 per cent. This ruling grade establishes an adjusted rating, westbound, of 3,470 tons between Bureau and Sheffield, requiring additional train movements between these points.

Automatic Control as Connected With the Signaling

In addition to the complete system of three-position automatic block signals in the train control territory the signaling includes two electric interlocking plants, one electro-mechanical and three mechanical interlockings, all of which are equipped with modern electric track-circuit locking. A contact ramp 80 ft. long is located approximately 65 ft. from each automatic and each home interlocking signal. The present installation includes 240 ramp locations, eight of which are intermediate ramps (which are described below) and two clearing ramps. The average distance between signals is 1.4 mi., the shortest block being 3,000 ft. and the longest block being 2.5 mi.

As the ramps are located close to the signals it was

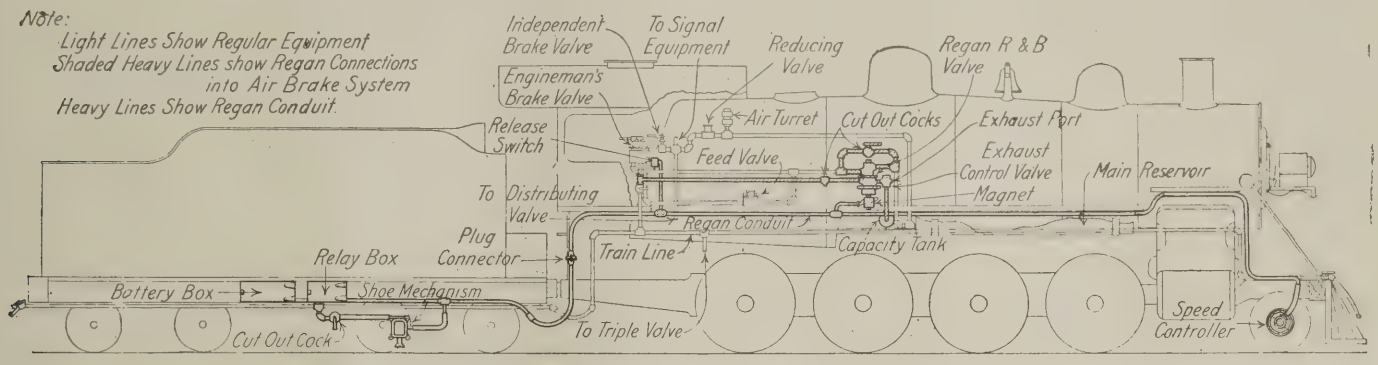
Rocky Mountain Limited Westbound in Train Control Territory

necessary to extend the line control circuit of each signal to give overlap protection into the next block. That is, a signal will now remain at stop until a train has passed through the block also proceeded into the next block the distance of the overlap. It is intended that these overlaps shall provide protection for "train stopping distance" with the service application of the brakes at the speed regulated by the train control apparatus, taking into consideration the gradient. The term "stopping dis-

Ramps Are 80 ft. Long and Located Approximately 65 ft. from the Signal

tance," as here used, is therefore somewhat different from the term "braking distance" which is required to stop a train at maximum speed.

Generally the overlaps were provided by changing the wiring of the signal system so as to include the first track section of the next block, although at some locations new track sections were required. The longest overlap in automatic territory is on a 0.41 per cent ascending grade and is 3,400 ft. long and the minimum is 1,375 ft. long on a 0.4 per cent ascending grade. At the interlocking plants there are no overlaps. However, approaching an



Showing Application of the Regan Apparatus to a Typical Locomotive

interlocking, an intermediate ramp is located between the distant signal and the home signal in order to obviate the overlapping of the distant signal within the home signal limits. At one interlocking, the ramp is 1,100 ft. from the home signal on a 0.4 per cent ascending grade. This is at a point where permanent speed restrictions are in effect. The maximum is 1,300 ft. on a 0.03 per cent ascending grade.

Ramp Circuits

A 10-volt battery is used with each ramp. At most of the locations this is a 16-cell caustic soda battery, although as a.c. power is available at Joliet, storage batteries on a.c. floating charge are used there. The feed circuit for the ramp is carried through a contact on the line relay and through circuit contacts on the signal mechanism; and the other side of the battery is connected to the rail. The circuit is completed so as to draw current only when a locomotive shoe passes over the ramp.

A contact device is provided at the ramp for the purpose of checking the position of the ramp. If the ramp should be knocked out of line 5/8 in. the control circuit of the signal in the rear is opened, causing the signal to go to stop; and consequently placing the ramp at that signal in a condition to stop trains.

Train Control Equipment on the Locomotive

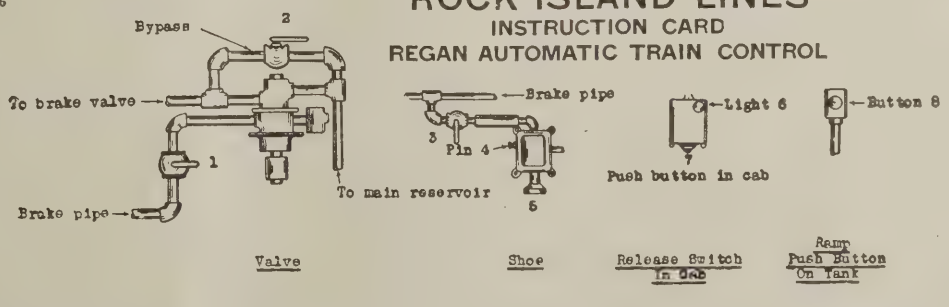
The engine equipment consists primarily of a contact shoe, an electro-pneumatic graduated valve, a speed controller, an indication selector and a storage battery. Stated briefly, the system functions as follows: The shoe, in riding up a ramp, opens an air port, operating the graduated valve, unless this valve is held closed by an electric circuit that is controlled indirectly by energy

FORM M. P. 36

ROCK ISLAND LINES

INSTRUCTION CARD

REGAN AUTOMATIC TRAIN CONTROL



1. TO CUT DEVICE OUT OF SERVICE: Close cock 1 so that handle is in line with pipe and open cock 2 on bypass so that handle is crosswise with pipe. In case of heavy leak of air at shoe box also close cock 3 so that handle is in line with pipe.

2. TO PLACE DEVICE IN SERVICE: Open cocks 1 and 3 so that handle is crosswise with pipe and close cock 2 on bypass so that handle is in line with pipe.

3. DOUBLE HEADING: When double heading, on rear engine Raise shoe stem 5 to full height; pull out locking pin 4, give it one-quarter turn and see that it has entered the slot full length.

4. OPERATION:

(a) The train control apparatus does not interfere with the proper observance of rules governing air brake operation.

(b) CAUTION SIGNAL will enforce speed throughout the block not to exceed 40 miles per hour for passenger trains and 30 miles per hour for freight trains. To avoid unnecessary application of the brakes, speeds should be maintained below these limits.

(c) STOP SIGNAL: At a stop block, ramp push button number 8 on tank must be pushed in before shoe engages ramp, and held in so long as shoe is on ramp. If stopped with shoe on ramp, button 8 must be pushed in and held in until shoe is off ramp.

(d) A stop signal will enforce speed not to exceed 15 miles per hour throughout the block for both passenger and freight trains. To avoid unnecessary application of the brakes, a speed should be maintained below that limit.

(e) RELEASE SWITCH IN CAB: Whenever device makes brake pipe reduction, place brake valve in lap position until train is running below prescribed speed; then when indicator light 6 is displayed, push the button 7 which will extinguish the light, and proceed to follow prescribed rules of proper air brake operation as though you had made the application yourself.

(f) IN CASE OF IMPROPER OPERATION: Should the device improperly apply the brakes, it must not be cut out of service until the ramp next ahead has been passed. The only exception to this rule will be permitted when, with the train at stop, it is impossible to release the brakes after pushing button 7.

(g) Report any improper working of the device to the Train Dispatcher and on work report.

The Instruction Card Placed in the Locomotive for the Guidance of the Engineman

from the ramp itself. The ramp circuit from the shoe is carried to an indication selector, which in turn controls the circuit which operates the graduated pneumatic valve.

While traveling between the ramp locations the indication selector is held in the last operating position by the local engine circuit, which is supplied with energy from a storage battery on the locomotive. At a signal indicating "proceed" the ramp supplies positive current consistent with that indication and no further action takes place until the next ramp is encountered. At a signal indicating "caution," negative current is supplied to the shoe, thus bringing into play the speed control features.

The medium speed for passenger trains is 35 m.p.h. and for freight trains 25 m.p.h. Trains are expected to enter a caution block at a rate below the prescribed rate. If this rate is in excess of the medium speed requirement then the brakes will be applied automatically, but after the speed has been reduced to a point below the medium speed, the brakes may be released and, if the engineman is alert, the train may be made to proceed through the block at or below this speed without a stop.

In case the train operates in a "caution" block to a speed above a medium speed requirement, then an automatic application of the brakes will take place. The engineman must then acknowledge the speed restrictive condition and release the brakes, after the speed has been reduced to a point below the prescribed medium speed, to allow the train to proceed under the restrictive speed; otherwise the train will be brought to a stop.

At a signal indicating "stop" the ramp is de-energized; hence, as there is no current for the shoe to pick up, it functions to cause the air pressure to be reduced in the train line to give a service application of the brakes. Upon encountering this stop indication the engineman may proceed through the block at a speed not to exceed 15 m.p.h. provided he acknowledges the condition. The system is designed not to require stopping at the signals indicating "stop" for those roads who may so elect to use the equipment.

Complete instructions for the government of enginemen concerning the train control operation are printed on a card as shown in the illustration and such a card is framed and mounted in each engine cab.

Rock Island Train Control Installation Approved

THE Interstate Commerce Commission on December 17 issued an order approving the installation of the automatic train control device of the Regan Safety Devices Company, Inc., on the Chicago, Rock Island & Pacific, Illinois division, between Blue Island, Ill., and Rock Island, Ill., 165.4 miles, double track, except for certain suggested changes concerning the signal system upon which the train control device is superimposed. As a result of inspection and test the commission finds that the device itself as installed meets all the requirements of the commission's specifications as contained in the order directed to 49 railroads on June 13, 1922. This is the first installation on one of the roads named in that order to be approved by the commission. The order establishes certain requirements as to inspection, tests and maintenance and the railroad company will be expected promptly to carry into effect the recommendations made with respect to the signal system.

The report, which is by Division 1, Commissioners McChord, Esch and McManamy, says:

The installation consists of an automatic train-control device of the intermittent electrical contact type. This device was first placed in service in March, 1920, on the Rock Island, between Blue Island and Joliet, Ill., a distance of 22.6 miles of double track road. The installation consisted of 20 equipped locomotives with 34 roadside ramps operating in connection with 32 automatic signals. From May, 1921, to March, 1922, this installation was under continuous observation by our bureau of safety and the American Railway Association.

Under date of February 24, 1922, we were advised by the Rock Island that the device had been in service between Blue Island and Joliet, Ill., for about two years and had done what its owners claimed for it, and that, at a meeting of the directors on February 21, 1922, the officers of the road recommended and the board of directors authorized and directed, upon approval by us of plans and specifications thereof, the extension of the automatic train-control installation from Joliet to Rock Island.

Under date of May 4, 1922, the Rock Island advised us that it was ready to install automatic train-control on its Illinois division between Joliet and Rock Island and transmitted in duplicate plans of the signal system in operation on this division, together with plans of the engine and circuits of the automatic train-control device of the Regan Safety Devices Company, Inc., and other information pertaining to the extension of the installation from Joliet to Rock Island with the request that the plans and information furnished be approved.

Under date of May 10, 1922, the commission approved the extension of this train-control system to Rock Island, a distance of 142 miles of double track. The installation was completed and placed in service on November 1, 1923, thus making a continuous installation between Blue Island and Rock Island, a distance of 165.4 miles of road, or 330.8 miles of track.

The roadside apparatus consists of a ramp located at each signal with the necessary wiring for connecting the train-control system with the automatic signal system; each ramp is provided with a ramp displacement device through which is carried the control wire for the next signal in the rear in such a manner that any displacement of a ramp is intended to open the circuit and cause the signal in the rear to assume the stop position.

The locomotive apparatus consists of the following:

1. A speed circuit controller of the centrifugal type the electrical contacts of which are set for speeds in accordance with the railroad company's requirements.

2. An electro-pneumatic brake valve with exhaust control valve and air capacity chamber which is interposed directly in the air supply line between main reservoir and the engineman's brake valve. It is also provided with a connection to the brake pipe. When the electromagnet of this device is energized that part of the valve controlling the brakepipe vent is closed and the part controlling the main reservoir pressure is open and main reservoir pressure is free to flow to the engineman's brake valve in the usual manner. When an automatic application is made the electro-magnet is de-energized, and main reservoir supply to brake valve is cut off to prevent releasing the brakes, and the brake pipe air vented to atmosphere via the exhaust control valve.

The exhaust control valve is so designed and constructed as to permit a 30 per cent reduction of the initial brake

pipe pressure, after which it automatically closes the brake pipe vent thus preventing the exhausting of the entire brake pipe system while providing for a service application of the brakes. In case it is desired to cut the train control out of service, by-pass air connections are provided, controlled by angle cocks normally sealed.

3. An electro-magnetic release switch and light indicator. The function of the indicator is to advise the engineman, after an automatic application of the brakes, when the speed of his train has been reduced to the enforced lower rate of speed, after which he may, by first operating the release switch, then release the brakes in the regular manner. The release switch is constructed so that it cannot be held closed, and its operation prior to reducing the speed of the train to the point where the indicator will be lighted will not effect a release of the brakes.

4. A push button known as the "stop ramp button." This must be operated in order to avoid an automatic brake application while going over a de-energized ramp, when passing a stop signal to enter a danger block at or below prescribed low speed. Exceeding the low speed limit will cause the brakes to be applied at any time in a danger block irrespective of the forestalling feature.

5. A shoe mechanism, on the right hand side of the locomotive for forward running, and on the left hand side for backward running. This shoe apparatus consists of a shoe stem and a circuit controller. The contacts of the circuit controller operate with the shoe stem and are closed with the shoe down and open with the shoe up, thus selecting between locomotive and roadside energy, but overlapping in their movement sufficiently to avoid breaking the indication selector circuit. The shoe stem is held down in position for contact with the ramp by means of air pressure. The shoe stem is drilled throughout its length so as to insure an application of the brakes in case it is broken off in service.

At a clear signal.—The shoe receives energy from the ramp to cause a clear or proceed indication to be transmitted to the engine apparatus, and this indication is maintained until the shoe engages the next ramp.

At a caution signal.—When the shoe engages the ramp energy of a different polarity actuates the engine apparatus to the caution position; and this indication is maintained throughout the caution block, and the speed circuit controller is automatically connected into the engine circuit in such a manner that it will operate an automatic service application of the brakes if the train exceeds the prescribed medium speed. When the speed has been reduced to the point at which the controller is set it operates to close a circuit to light the cab indicator, thus notifying the engineman that he may take the proper action to release the brakes. Should he for any reason be incapacitated, or fail to take advantage of this opportunity, the brakes would continue to apply and stop the train.

At a stop signal.—The shoe receives no energy from the ramp and the engine circuit is opened, thus causing an automatic application of the brakes. However, a stop signal may be passed and the train enter the danger block without receiving a brake application if two requisites are complied with, namely, "stop ramp button" must be held closed while the shoe engages the stop ramp, and the train must be operating at, or below the prescribed low speed. The train may then proceed and is automatically restricted throughout the danger block to the low speed limit the brakes applying automatically whenever the train exceeds that speed. After each automatic application of the brakes the cab indicator will light when the speed has been reduced sufficiently for the engineman to effect a release; if no action is taken the brakes will continue to apply and stop the train.

Our order in *Automatic Train-Control Devices supra,* provides:

"That each installation made pursuant to this order shall, when completed, be subject to inspection by and the approval of the Commission or any division thereof to which the matter may be referred."

This device has heretofore had the commission's approval. Therefore, the purpose of this inspection and test was to determine if the installation was made in accordance with the plans furnished and the specifications and requirements of our order. As a result of this inspection and test it has been found that the device itself as installed meets all the requirements of the commission's specifications and order in *Automatic Train Control Devices supra* and its installation is, therefore, approved, except as hereinafter indicated.

The Rock Island will be expected to comply at once, with the following requirements as to inspection, tests and maintenance. (1) To insure the proper and safe operation of the locomotive apparatus, arrangements should be made by the railroad for a careful inspection and tests of the train control equipment by skilled employees on the arrival of all locomotives at a terminal or roundhouse. This inspection and tests should include all parts of the apparatus; all sealed air cocks should be inspected to see that the seals are unbroken and that the apparatus is properly cut in service before leaving. A daily report as to the conditions of the apparatus should be made on a form especially provided for that purpose and forwarded ed by the inspectors to the proper authority. (2) The roadside apparatus should be frequently inspected and tested for crosses, grounds, and polarity, the alignment of ramps and the proper adjustment of the displacement detector and a report made on a form provided for that purpose and forwarded by the inspectors to the proper authority. (3) A form should be provided for the engineman on which to report all failures of the apparatus or any irregularities in the operation of the device. (4) The shoe housing and other accessible parts of the apparatus should be padlocked or sealed.

Certain situations were noted which, in our opinion, should be corrected by the railroad company as a precautionary meaure in order to secure a greater degree of safety and to prevent a possible failure properly to protect train operations, in so far as it concerns the signal system upon which this train control device is superimposed. In the following specific respects the railroad should promptly take the necessary action to carry into effect the recommendations made:

(1) Location of clearing ramp when leaving train-control territory at signal 162 should be changed so as to provide protection for a train standing in the overlap of signal 170.

(2) All cross-over switches between main tracks and sidings should, when used, be so arranged as to give maximum protection to main track traffic, through the proper signal indication.

(3) All movements leading to main tracks should be protected through the signal system.

(4) Movements by signal indication through all interlocking should be at low speed except that where a

more favorable indication is desired full train control protection should be provided through the signal system. The train control ramp indication should be made to conform to the signal indication, opposing signals should not be cleared simultaneously.

(5) Some of the signal overlaps, in our opinion, are not of sufficient length to provide braking distance at the present medium speed.

(6) The medium speed of 37 miles per hour for passenger trains is, in any event, considered too high and a lower speed is recommended.

(7) Protection should be provided against a train on siding, following a train on the main track, without restriction as to speed.

(8) Sign boards should be placed to indicate the beginning and ending of automatic train-control territory.

While these recommendations do not reflect upon the train-control device itself, we feel that as a matter of caution the carrier's attention should be called to them and it should comply therewith in order that the greatest degree of safety may be insured. The attention of the Rock Island has been called to these matters and they indicated their willingness to comply with our recommendations in reference thereto.

Electrical Repair Work on the Grand Trunk

Good Facilities and Systematic Procedure Important Factors in Keeping Down Maintenance Costs

IN the shops of the Grand Trunk Western Railway Co., at Battle Creek, Mich., the electrical department has put into service a number of interesting practices which make for speed and thorough handling of all electrical repairs. One of the most important factors in facilitating electrical repair work is a system of keeping track of various armatures as they pass through the shop from the time they are first received until they are ready for shipment. In Fig. 1 may be seen a rack or frame built up of pieces of angle iron welded together. Arms extend outward on either side of this frame and these arms are used to support the armatures as shown in the illustration. When the carlighting armature is received for repair, it is taken from the box and a tag made out for this particular armature. This tag contains all of the information connected with this armature, such as the number of the armature, requisition number, car from which it was taken and when it was received. This tag is then put on the first hook at the top left hand corner of the rack. Each time the armature is moved, the card is moved over to the proper hook to indicate at all times just what the progress of the work is for that particular armature. When the work has all been completed, tag is filled out with the material used and the time required to do the repair work. The date on which it was shipped is also recorded and finally this tag is put on file in the chief electrician's office. The designation of the hooks along the top of the rack are shown in Fig. 2.

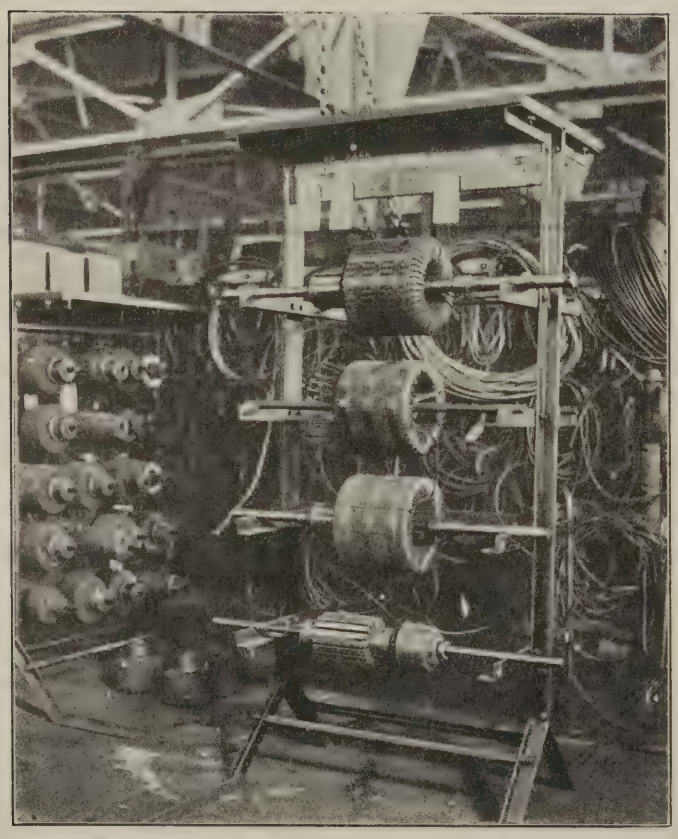


Fig. 1—The Rack Upon Which Armatures Are Placed When Sent in From the Road for Repair

In testing armatures which are largely of the Stone Franklin make, the armature is placed in the housing of the testing rack dynamo shown in Fig. 3 and run over a half day with a load of 50 amperes. On this testing rack, any speed can be had that is desired. The motor which operates the armature under test is a Western Electric 7½ hp. machine. A Cutler-Hammer controller, seen on the right hand side of the illustration, controls the motor and regulates the speed according to the position of the handle. At the top of the frame is located the main circuit breaker which is in the driving motor circuit and which opens up in the event of an overload. This running test is made for the purpose of detecting any loose commutator bars or any other loose connections in the commutator and this is readily accomplished as the armature is under full load all the time. The load used in this test is made from a bank of lamps mounted on a rack not shown in the picture.

On Rack			Off Rack			
Not Started	Under Repair	Ready to Ship	Under Repair	Turning Commutator	On Test	Boxed for Shipment

Fig. 2—Arrangement of Hooks on Armature Receiving Rack

Testing Headlight Armatures

Another practical testing feature is seen in the method used for testing headlight generator armatures. On a

small switchboard, Fig. 4, is located an alternating current electro-magnet designed so as to permit the armature of a Pyle National generator to be slipped over a stud in such a way as to be centered between the two arms of the magnet. The circuit which is connected to the winding of this magnet through a single pole knife switch supplies alternating current at 440 volts, 60 cycles. When the current is on, the armature is in a strong magnetic field and by revolving it slowly, and making a short circuit test, from bar to bar, any defect in the winding becomes quickly apparent. Of course, in short circuiting adjacent commutator bars with a piece of wire, sparks are produced where the wire touches the commutator bars, and it is by the intensity of these sparks that the condition of the winding is judged. Any short circuit in the winding, however, will readily manifest itself without any external test. Since the armature is in a rapidly changing

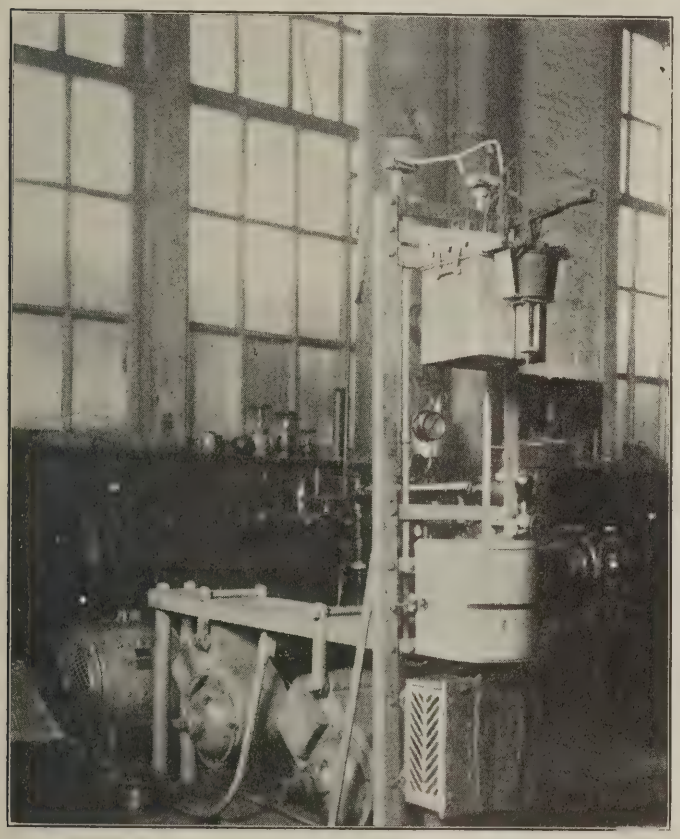


Fig. 3—Testing Frame Used for Testing Out Repaired Axle Generator Armatures

field, heavy currents will be set up in a short circuited coil and the armature will become hot, so hot in fact that the insulation will begin to smoke. The principal advantage of this form of testing is that it can be done very quickly and faults located in the shortest possible time. The test magnet itself is made of laminated iron built up to about two inches in thickness. The height of the magnet is approximately 10 inches and the core which extends through the coil has a cross section of about 9 square inches. The coil is composed of 240 turns of No. 11 Deltabeston wire.

The headlight generators, which are taken from engines under repair in the shops, are first overhauled, repairs made and new parts put in where necessary. They are then given a test run on a testing frame not shown in the picture but which is connected to the frame shown in Fig. No. 5. The steam pressure used in making the test is 110 lb. The governor is set for the proper speed to make sure that the voltage is right and the machine run for a time and any adjustments are made that are necessary, so that when the machine leaves the testing frame it is in readiness to go on the locomotive again.

In testing field coils and armatures, they may be quickly and easily placed in the dynamo shown in Fig. No. 5

Fig. 4—An Alternating Current Electro-Magnet Used for Testing Armatures of Headlight Generators

and given a test run and their performance noted under operating conditions. The front field frame of this outfit is hinged so that it can be swung open and an armature or field coil put in without the trouble of lifting the frame away from the machine and laying it to one side. Another simple feature of this outfit is a small handle shown near the top. This handle is made by welding a

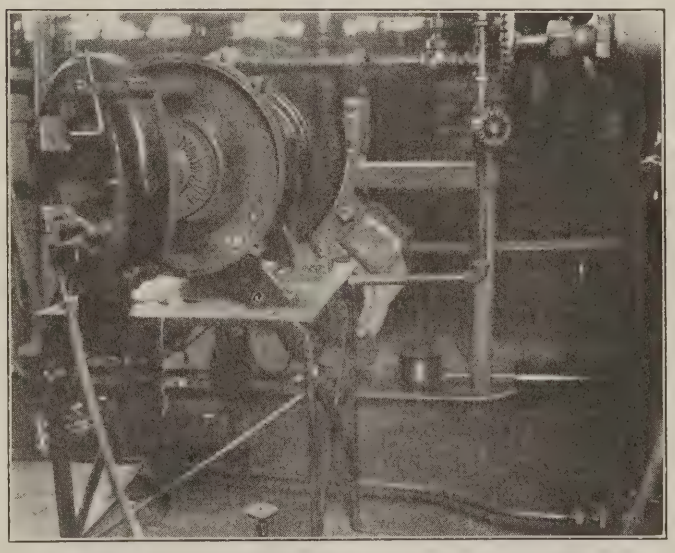


Fig. 5—Frame of a Pyle National Turbo-Generator Used for Testing Repaired Headlight Armatures and Field Coils

piece of round iron to the head of one of the frame bolts so that the latter may be quickly run in, thus bringing the swinging part of the frame tightly against the stationary part. It will be noticed also that the front end of this handle is made into a socket wrench. This wrench fits the cap bolt in the end of the shaft that holds the armature on. In this way, this little piece takes the place

of three separate pieces, that is, two wrenches and one field frame bolt. Using this saves considerable time and also lessens the chances of losing the extra parts.

Headlight armatures that are to be shipped out to the different terminal points on the road are put in specially constructed armature boxes, so constructed that the winding on commutators cannot get damaged during shipment.

Winding Equipment

As much of the work of the department consists of winding, there is nothing more essential than the machinery to do this kind of work. Most of this apparatus is shown in Fig. 6. At the extreme left of the illustration will be seen the wire reels. The wire is led over to the coil winding machine which is on the left hand end of the table. This machine is so made as to be adjustable for any size coil that it is necessary to wind. When a machine is received that needs rewinding some of the old coils are removed and one of these put on the winding machine as a method for getting the proper length of a new coil. By this means, the newly wound coil is certain to fit exactly into the space previously occupied by the old coil. After the coil has been wound, it is shaped on the shaping machine which may be seen at the far side of the table. This machine is likewise adjustable and a coil having been placed in it can be drawn out to the desired shape so that it will span the correct number of slots in the core of the armature or stator as the case may be.

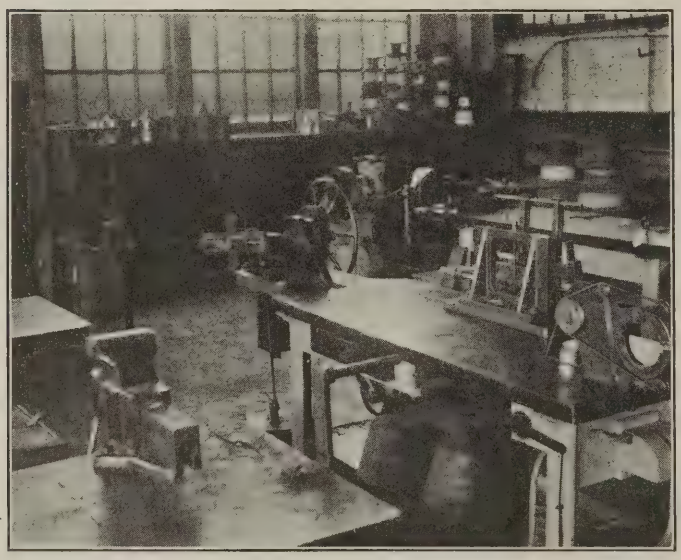


Fig. 6—Equipment Used in Winding New Coils for Armatures and Induction Motors

The machine shown at the extreme right of the table is a taping machine by means of which the coil is taped very rapidly after it has been shaped.

A unique scheme is shown in Fig. 7 for dressing up the end winding of a rewound stator. In order to give each coil the same formation at the exposed ends, two conical shaped blocks are placed in either end of the open stator and a threaded rod passed through. By means of nuts, the blocks are drawn together and in this way the ends of the coils are forced to assume the same shape. The conical wood blocks are so tapered that they can be used for practically any type of induction motor that comes to the shop for repair.

Testing Rewound Rotors and Armatures

A device similar to that used for testing headlight generator armatures is used for testing armatures of larger sizes. It is an electro-magnet designed for use on an alternating current circuit at 440 volts, 60 cycles. The general construction of this piece of testing equipment can be seen in Fig. 8. The thickness of the laminations is about 6½ in. The greatest height is 8½ in. and the greatest breadth 10 in. while the part which passes through the coil is 3 in. by 6 in. in cross-section. The winding consists of about 300 turns of No. 11 Del-

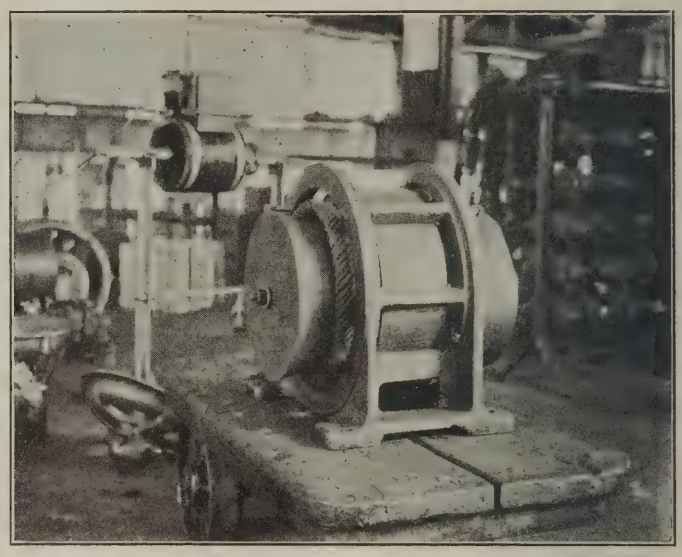


Fig. 7.—Conical Shaped Blocks Are Used to Dress the Ends of Repaired Stator Windings Evenly

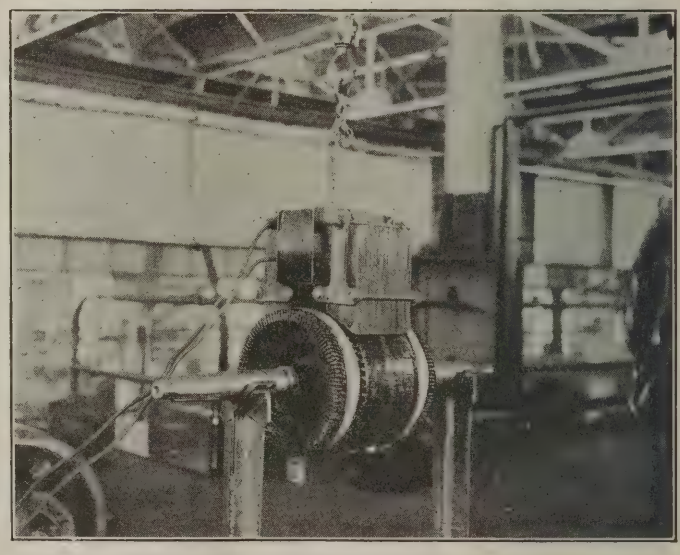


Fig. 8—Alternating Current Magnet Used in Testing Windings of Armatures

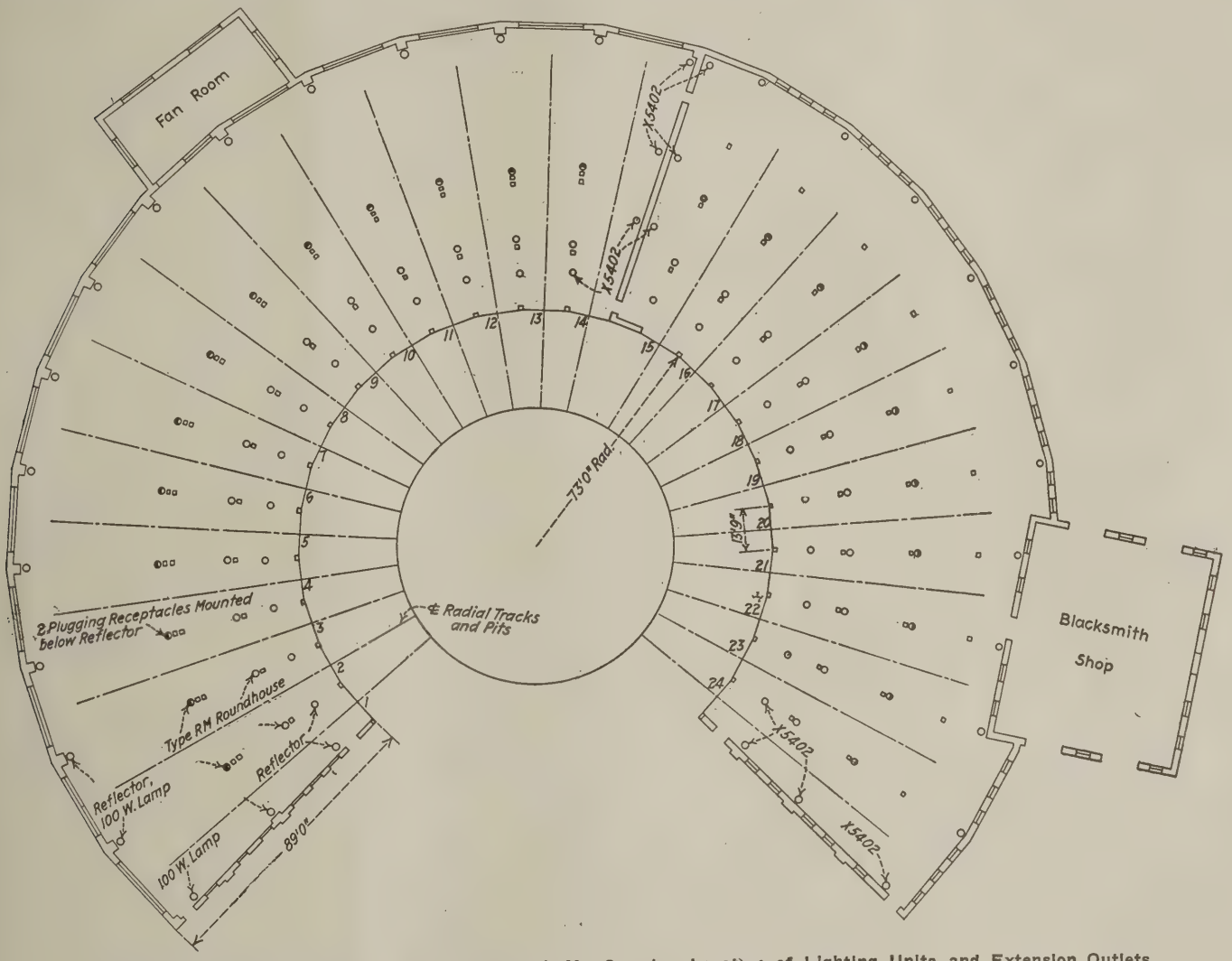
tabeston wire. In testing an armature of a motor, the "growler," as it is called, is raised by means of a chain hoist and placed over the armature as shown. Improperly wound coils or wrong connections will manifest themselves by undue heating. In testing carlighting generator armatures bar to bar tests can be made in the same manner as was done with the headlight generator armatures.

This shop is so equipped that they are able to do any or all electrical repairs necessary for the road.

Enginehouse Wiring and Lighting on the Santa Fe

Lead Coated Wrought Iron Pipe Is Used for Conduit. Threads and Fittings Are Lead Coated by Wiremen

A METHOD for wiring enginehouses has been developed and adopted by the Atchison, Topeka & Santa Fe which meets with all the requirements of the National Electric Code with regard to workmanship and material and which also seems to fulfill the most difficult requirements for an enginehouse wiring and lighting installation that will last; that will not be destroyed by the action of locomotive gases. All wires are carried in lead coated, wrought iron water pipe and both wall type and overhead type reflectors are used, the location and size of the reflectors and lamps being varied to suit local requirements. Angle reflectors are used on the section end walls.



Floor Plan of Santa Fe Enginehouse at Raton, N. M. Showing Location of Lighting Units and Extension Outlets

Conduit

The conduit which is used consists of standard wrought iron water pipe which has been given a coat of lead inside and outside. Two processes for leadizing pipe were developed in the test department of the Santa Fe. These were described in the May, 1923, issue of the *Railway Electrical Engineer*.

The conduit system when installed is complete to each switch, fixture or other outlet and is grounded. The inside dimensions of the pipe are made to conform with dimensions for wires encased recommended by N. E. C. rule 28, section "i." Each section of the conduit system is completely installed, including all outlet boxes, fittings, cabinets, etc., before the wires are drawn in. When using pipe leadized by the hot dip process some difficulty was experienced when drawing in wires due to beads of lead, but this difficulty is not encountered when the lead acetate process of treating pipe is used. Formed elbows, standard couplings, and approved unions are used. The couplings are made to conform with a standard steam pipe joint with at least five threads engaging and running threads are not permitted.

The conduit is generally run exposed on the walls, trusses and columns of the building and is supported by straps spaced five feet apart where practicable. Screws are used for securing pipe straps to wood supports and on masonry, expansion bolts or screw anchors are used.

Leadizing Threads and Fittings

The pipe is cut on the job by the wiremen and the ends reamed. All fittings, pipe straps, screws, bolts and other metal detail material and all pipe threads cut on the job are leadized by the wiremen. Cabinets for panel boards and reflector cases are not leadized but are painted inside and out with acid resisting paint.

The leadizing done in the field is usually done by the lead acetate method as follows:

First:—Clean the article thoroughly, removing paint and oil. This may be done by immersing in a hot solution of about three-fourths pound of powdered lye to one gallon of water. Ordinarily this works quite rapidly. The solution must be kept hot.

Second:—Pickle all units thoroughly in muriatic acid, then wash acid off with water.

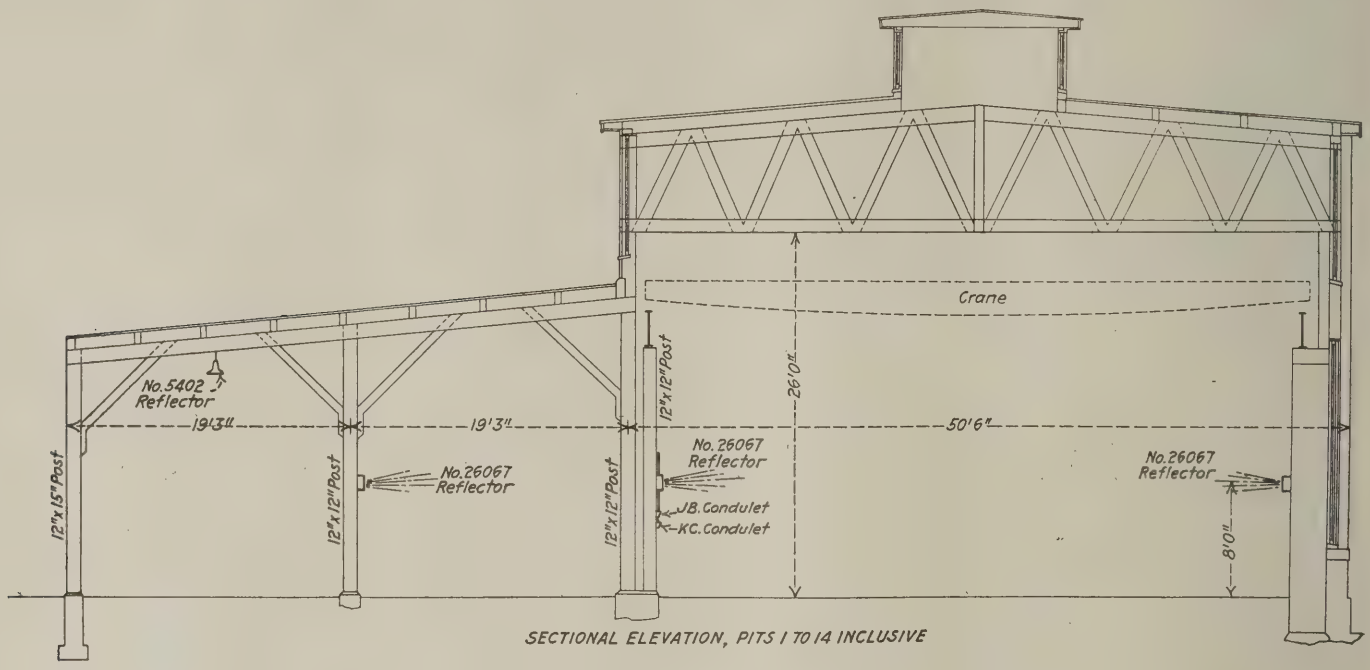
Third:—Immerse the article in a saturated solution of lead acetate until a satisfactory coating is obtained. Ordinarily this requires about forty minutes.

The lead acetate solution is made up in proportions, approximately, of:

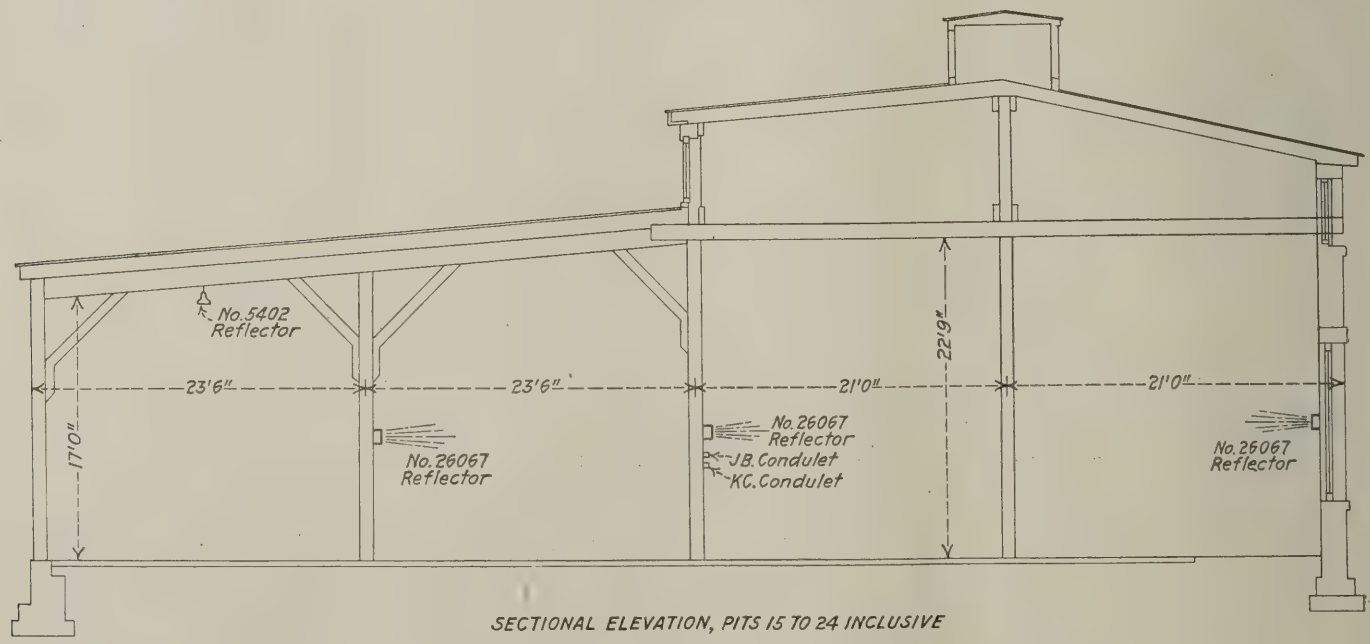
70 pounds lead acetate (crystallized)
30 pounds water
5 pounds muriatic acid

The lead acetate solution should be kept at a temperature of from 180 to 200 degrees Fahrenheit, but should not be boiled to avoid losing acid. Acetic acid may be used instead of muriatic acid.

As the solution "runs down" more acid and lead acetate should be added to keep the solution saturated. The coating must be dense and hard, and of a grey color; a spongy or crystalline deposit, easily rubbed off, is not satisfactory and indicates the need of more lead acetate in the solution.



SECTIONAL ELEVATION, PITS 1 TO 14 INCLUSIVE



SECTIONAL ELEVATION, PITS 15 TO 24 INCLUSIVE

Sectional Elevations of Santa Fe Enginehouse at Raton, N. M. Showing Location of Lighting Units and Extension Outlets

Zinc must be removed from galvanized material before attempting to leadize, as a satisfactory lead coating cannot be obtained over zinc. Certain enamels and paints used in finishing fittings are quite difficult to remove. Hydrochloric acid is required to remove zinc and some paints and enamels may be removed by soda solution. Where possible, material should be obtained from the factory without galvanizing or other coating.

The equipment for the process consists of containers for the solutions and rinsing water, with necessary heating apparatus. Five gallon pails have been found satisfactory for small jobs and half barrels with ½-in. copper pipe steam coils for heating have been used satisfactorily.

Wiring

Lighting service is generally 115-230 volts 3 wire alternating current. The former practice was to carry a feeder circuit around the outside of the house on bracket supported cross arms, using weather proof wire on glass petticoat insulators, but where it can be done at less cost, a condition frequently found, the feeders are now being carried in leadized pipe inside the building.

The wire used in the conduit is a high grade wire with 600-volt insulation. Single braid insulation is used for sizes No. 8 B & S gage while double braid insulation is used for larger sizes. Stranded conductors are used for No. 6 and larger sizes.

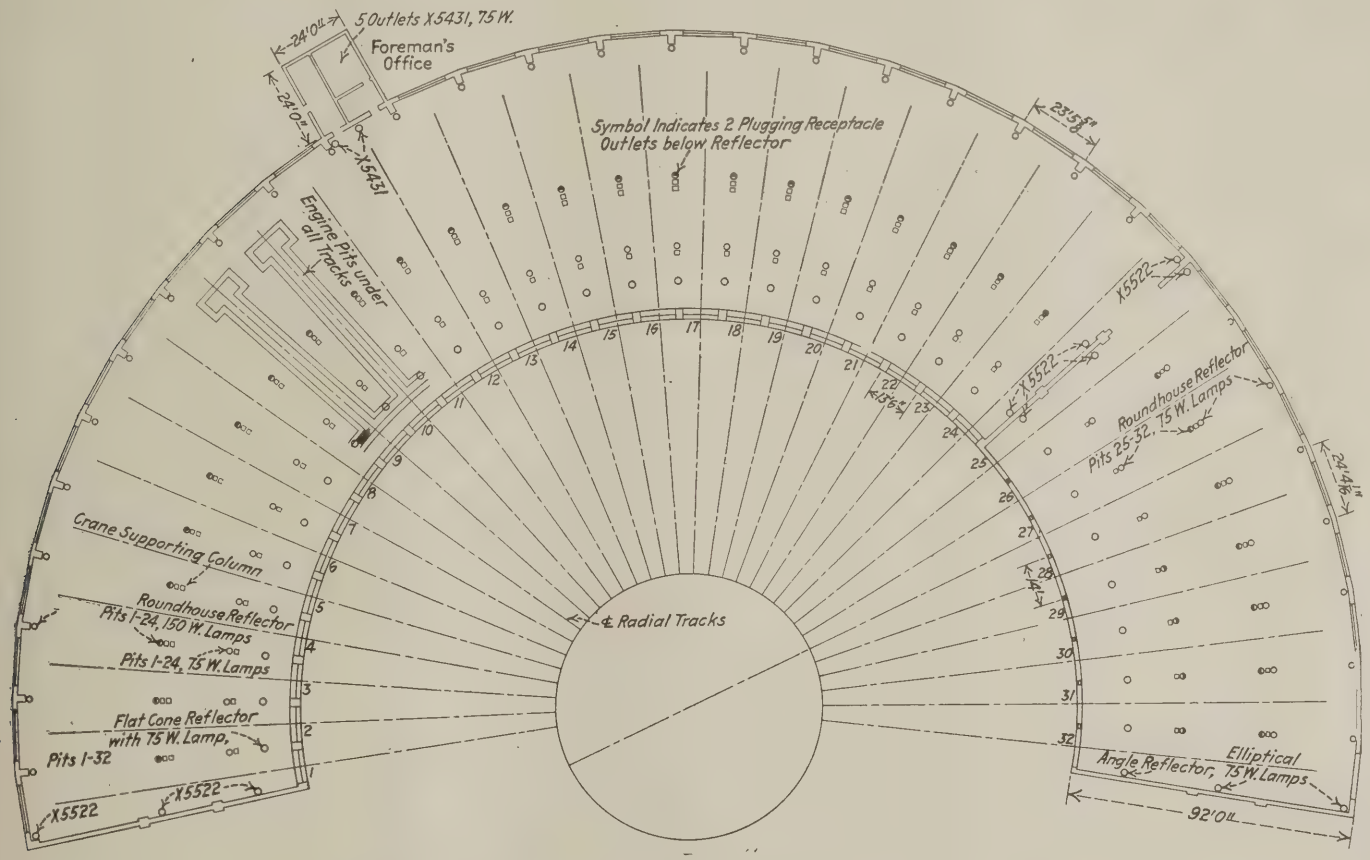
No joints are pulled into the conduit and all joints and splices in junction boxes and outlets, after being made mechanically and electrically secure, are soldered with half and half solder and taped with rubber tape and friction tape. One conductor of all the lighting circuits is grounded and this conductor is identified by an identifying marker which is woven into the braid of all of the smaller wires. Permanently secured tags or paint are used for some of the larger wires, where the identifying marker in the braid is not available.

Switches, Cabinets and Junction Boxes

The main service switch consists of a cast metal externally operated switch. Switch control of the branch lighting circuits is from dead front safety panel boards which have a 3-wire main and 125-volt, 2-wire branches with tumbler switches and Edison plug cutouts in the branches and tumbler switches in the mains. These panels have a slate frame and are enclosed in a steel cabinet.

All branch lighting circuits are 2-wire circuits; the load on each is limited to 660 watts and 6-ampere fuses are used. For switching branch circuits other than at the panels, H and H switches mounted on condulets are used. These are mounted on the outer circle wall or on the columns, care being taken not to place them on a column on which there is steam, air or water piping. Plugging receptacles for portable lights are on separate circuits from lights and not more than eight receptacles are connected to one circuit.

Cast iron outlet and junction boxes are used with cast covers which are either gasketed or threaded. The boxes are supported independently of the support afforded by the conduit. A locknut inside and outside and a bushing inside are used on all conduits entering boxes, cabinets and fittings except where such precaution is rendered unnecessary by the design of the box or the fitting.



Floor Plan of Santa Fe Enginehouse at La Junta, Colo. Showing Location of Lighting Units and Extension Outlets

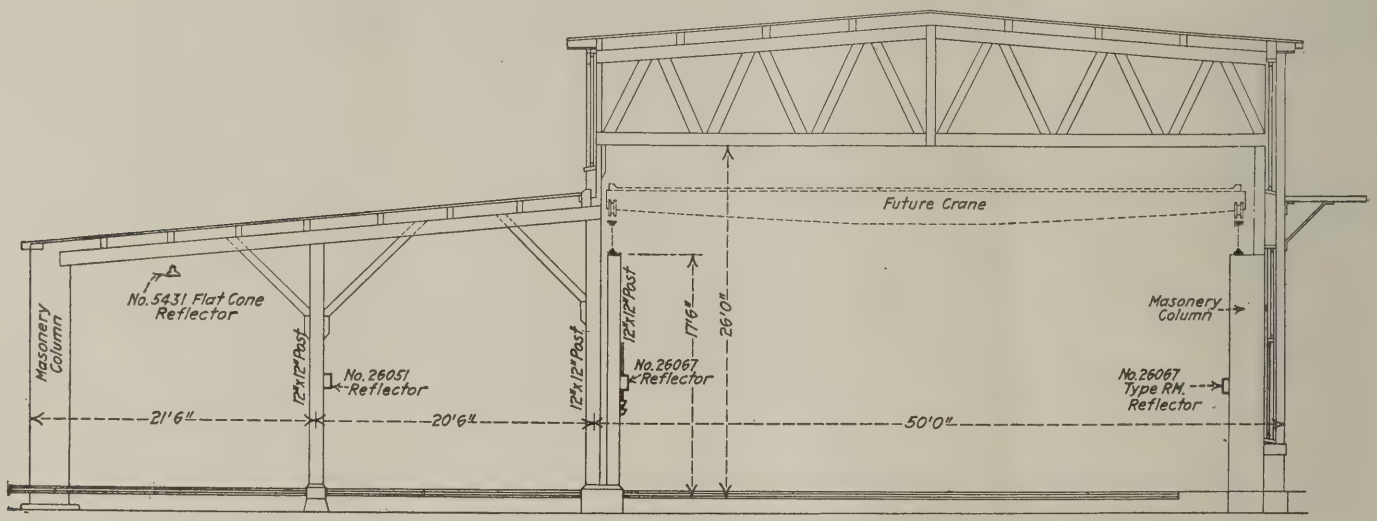
Outlets

The illustrations show the floor plan and two sections each of the enginehouses at La Junta, Colorado, and Raton, New Mexico. The installations are typical of Santa Fe practice and show the location of all of the lighting units and the extension outlets.

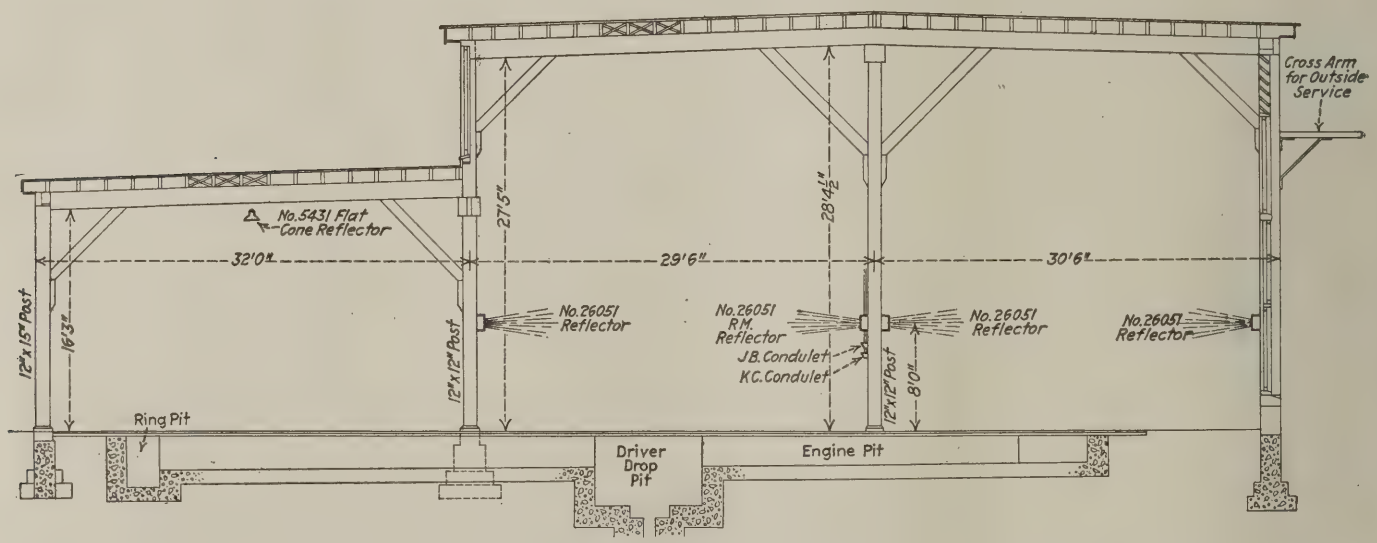
The greater part of the lighting is provided by the horizontally mounted roundhouse reflectors which are placed on the columns and outer circle wall, eight feet from the floor. Three or four of these units are used between adjacent pits, and 75 or 150 watt sizes are used depending upon the area to be lighted. The steam and smoke in the building does not often interfere with the light from these units and they are mounted low enough to be comparatively free from the corrosive action of the locomotive gases. Furthermore the 8-ft. mounting height makes maintenance easy and the units can be kept clean with little difficulty.

The overhead flat cone reflectors mounted near the inner circle wall provide light for the narrow space between the tanks and light the tops of the tanks. The smoke and gas at this point is seldom bad and the overhead light provides good light which it would be impracticable to obtain with horizontally mounted reflectors in the narrow space between the tanks. Flat cone or elliptical angle reflectors are used to light the space between the section walls and the adjacent locomotive. Two extension outlets are installed between adjacent pits. In special cases there are four extension outlets per stall.

The illumination for the entire house is effective at all times and the wiring system is one which gives promise of lasting for many years. This lighting plan has been used for about eight years but the use of lead treated pipe was only started about three years ago. While it cannot be definitely concluded that the leadizing process has solved the problem of conduit deterioration the results so far have been very encouraging.



SECTIONAL ELEVATION, PITS 1 TO 23 INCLUSIVE



SECTIONAL ELEVATION, PITS 25 TO 32 INCLUSIVE

Sectional Elevations of Santa Fe Enginehouse at La Junta, Colo. Showing Location of Lighting Units and Extension Outlets

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Recent developments in India seem to indicate that the demand for electrical goods will be on an unprecedented scale in the near future, and the importance of having stocks available at competitive prices in the principal port cities of India cannot be too strongly emphasized.

Miller Train Control Stop and Speed Equipment

New Positive Stop Valve and Pressure System of Speed Control Among Recent Developments

A PNEUMATIC manual release positive stop valve to be mounted outside the locomotive cab, and a reversing mechanism to give proper protection for either forward or backward movements, are some of the latest features recently developed by the Miller Train Control Corporation. These are additional features to the Miller equipment as in service on the Chicago & Eastern Illinois. In order to convey an idea of the functions of the new features a brief description of the complete apparatus is given below:

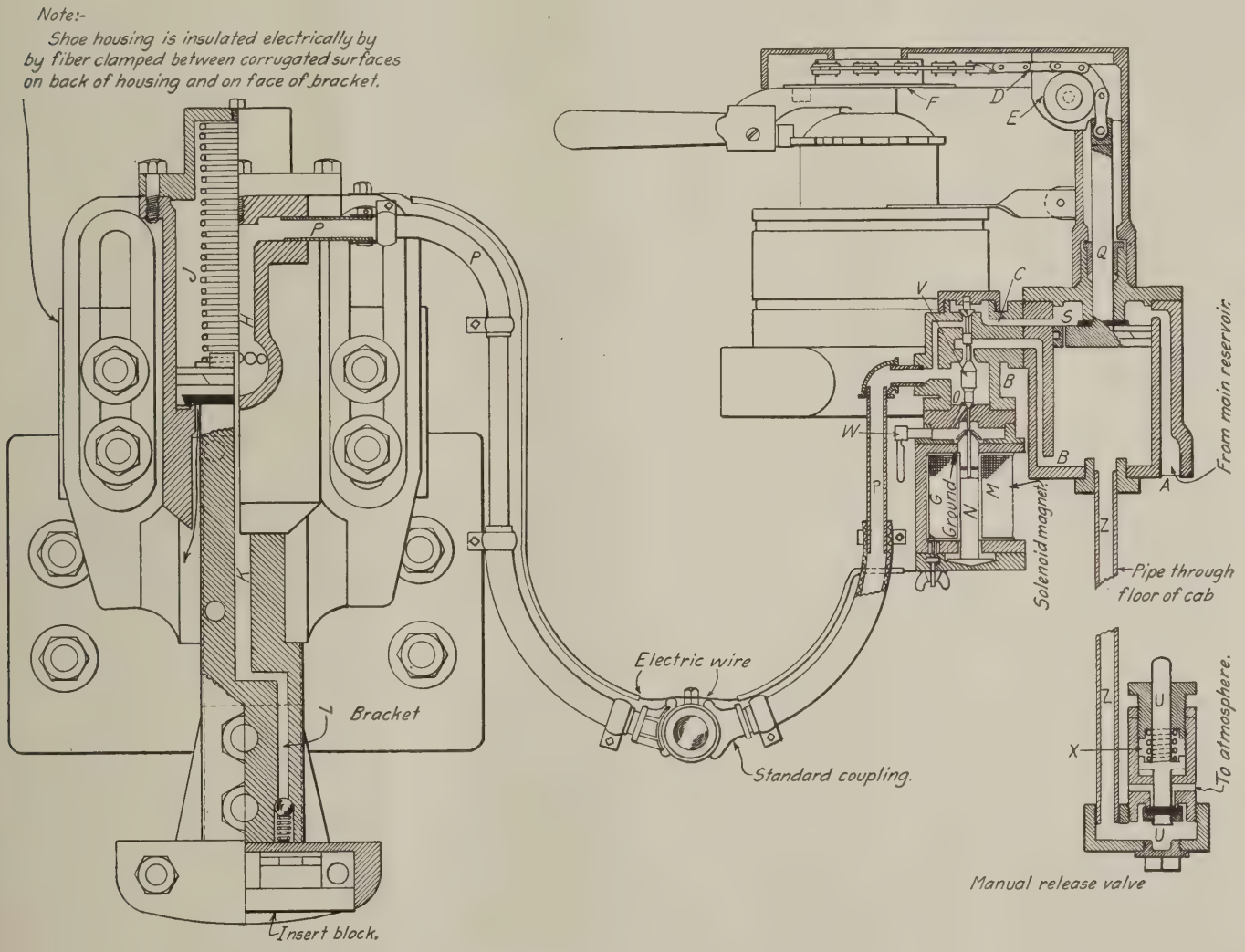


Diagram of the Miller Train Control Apparatus Including the New Release Valve

Description of Air Passages and Flow of Air Through Control

Air is taken from the top side of the main reservoir air line in the cab through a special air strainer and through a special cut-out valve which is provided with a suitable means for sealing in the open or closed position. Air enters the control at *A* and proceeds through to the top of piston *Q*, flowing through port *S* into the bottom of the cylinder under the piston; then through chamber *B* to passageway over and around valve *V* into pipe *P* and through the hose connections into the shoe housing, through port *H* into cylinder *J* on the top of piston *T*. Piston *T* makes an air seal when the gasket makes contact with the shoulder seat in the bottom of cylinder *J*. Port *K* in the shoe bar also fills up and the terminus of air in the shoe bar itself is at the small ball valve *L*. Shoe bar *T* is drilled with port *K* terminating in the small ball valve *L*, which is normally held against this port by spring tension. Should the shoe be broken or become loose, air would force ball valve *L* from its seat and the air, exhausting to atmosphere through port *K*, would cause the control to function to a stop. Air also flows directly from the ports of the control cylinder through pipe *Z* to the manual release valve *U*, which holds this valve normally closed. A small amount of air flows from the top of piston *Q* into port *C* and around valve *Y*.

In the design and installation of valve *U*, in the manual release, consideration has been given to its proper location. A small air pipe is carried from the plug in the

bottom of the control cylinder and located close to the side of the boiler and the valve is so installed and protected that there is no danger of freezing. A plug has been provided in the bottom chamber of valve *U* for drainage or clean-out purposes. All of these parts are under main reservoir pressure while in normal position, i. e., with the control piston up, the valves and magnet all down, and the shoe bar at its lower position.

When the shoe contacts with an energized ramp, electric current flows from the ramp through the shoe and wire connections to the binding post on the control magnet through the magnet winding to ground, through the wheels of the locomotive to the rail and through the wire connection back to the opposite pole of the battery. Failure of the ramp circuit, or failure of the electrical circuit on the engine will give a stop indication.

When the shoe is in contact with an energized ramp, solenoid magnet *M* receives current, plunger *N* is moved upward, lifting the valve *V* from its lower seat, opening the small port *O*, and air passing through this port causes the whistle to blow, thus giving an indication that the ramp in energized and that there is a clear block ahead. The upward movement of valve *V* closes port *B*, thus preventing a reduction of air under piston *Q*, and at the same time raising valve *V*; this allows main reservoir air to flow from port *C* into chambers *B* and *J* and pipe *P*, giving a rapid equalization, thereby preventing any movement of piston *Q*, when magnet *M* is de-energized and valves *V* and *Y* and plunger *N* return to normal.

Operation of Control Over Stop Ramp Using Positive Stop Valve

When the shoe is moved upward, air exhausts to atmosphere through port *H* under piston *T* between the shoe bar and the housing and causes a reduction of air in cylinder *J* and pipe *P* from chamber *B* under the control piston. Air pressure on top of the piston *Q* causes the piston to be forced down, and through the chain and chain plate connected to the handle of the engineman's brake valve, moves the handle to the service position. This reduction of air also takes place in pipe *Z* connecting the control with the new positive stop valve *U* and because of this reduction, valve *U* is forced open by spring *X*, leaving the ports in this valve open to atmosphere. As the shoe resumes its normal position, thus closing port *H*, further reduction of air in cylinder *J* and pipe *P* is prevented, but valve *U* being open there is a direct flow of air from chamber *B* to atmosphere, and piston *Q* is pneumatically held in its downward position, the brakes being retained in service until the train stops and the valve *U* is manually closed by the engineman from the ground, whereby air flowing through port *S* will equalize the pressure under the bottom of piston *Q* and it will resume its normal release position.

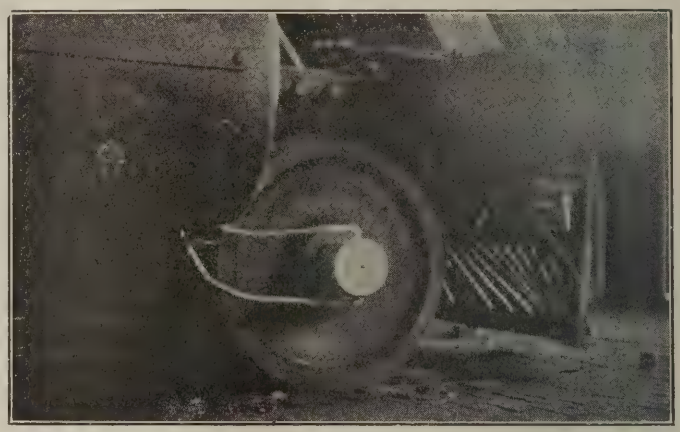
Operating Backward in Direction of Traffic

To provide for operation on locomotive backward in the direction of traffic, ramps may be placed on each side of the track and electrically connected to the signal system, and with a shoe on each side of the engine. These shoes are designed and so connected with the control and reverse lever that when the lever is in the forward position the right hand shoe is down and operative; the left hand shoe is cut out and raised automatically to full clearance and rendered inoperative. When the reverse lever is in the backward motion, the left hand shoe is down and operative and the right hand shoe is cut out and raised automatically to full clearance and rendered inoperative.

The control pipe to the shoes is connected into a three-way valve which is so designed and connected to the reverse mechanism by a slot arm and crank that the air line is continuous to the proper shoe in respect to the position of the reverse lever, and the opposite shoe is cut off from the air line, while a spring in the housing of sufficient strength to lift and hold the shoe, bar and piston in uppermost position becomes operative.

Speed Control Device

A speed control device designed to be used as an adjunct to its present automatic stop system of train control as operated on the Chicago & Eastern Illinois and in connection with the positive stop valve as approved by the Interstate Commerce Commission, has been developed and has been in service for nearly a year. Speed control is obtained through the medium of a pressure or oil flow system. A steel flange is centered and bolted to the end of the axle of one of the truck wheels to carry a self-contained gear pump. The gear pump is housed in a dust-proof and weather-proof case, carried by the outer ring of a



A Self-Contained Gear Pump Is Mounted on the End of the Pony Truck Axle

large ball bearing, the inner ring of which is securely attached to the steel hub on the axle. Two ⅜-in. pipes are carried from this pump back along the running board of the locomotive to a point adjacent to the cab where the speed control mechanism is located.

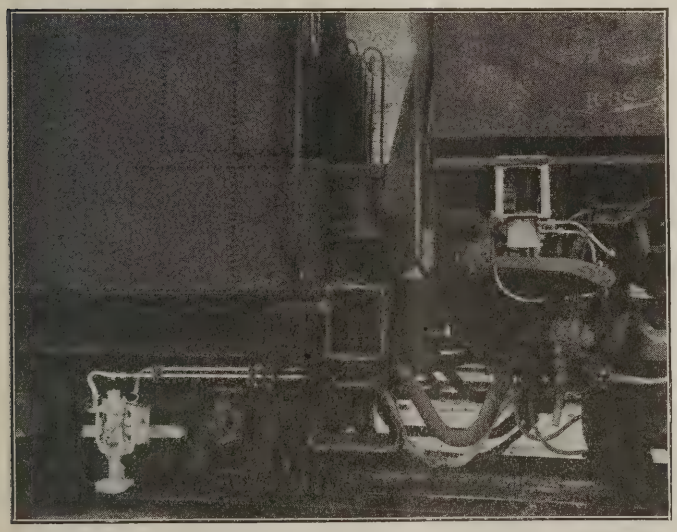
This mechanism consists of a suitable cam and latches to provide for the different functions. The travel of the parts is obtained through the medium of a piston with an automatic metering valve through which a non-freezing fluid flows from the pump, and allows the piston to travel in an upward position in accordance with the speed and rate of flow of the fluid. This fluid overflows into a weather-proof case surrounding the piston mechanism which acts as a reservoir and from which it flows to the pipes, through the pump and then back to the cylinder underneath the movable piston.

When the locomotive is standing still the apparatus is at its normal or zero position. As the locomotive is moved in either direction the fluid flows from the reservoir through the pipe and pump into the cylinder under the piston. As soon as the fluid begins to flow, the piston starts to move upward. Its total range of movement is approximately three inches. High or maximum speed

restrictions, when used, are obtained when the piston has reached approximately the full length of its travel. However, the speed range is adjustable and no maximum speed limit need be provided unless desired. It is claimed that experience has shown that the operation of this piston is slow, positive and reliable.

As the piston moves upward it rotates a pair of disks mounted on a shaft. On the periphery of one of the disks a cam or ball is milled so that when the mechanism is in a position corresponding to a maximum speed set-up the cam comes in contact with a bell crank; as this crank is moved outwardly the opposite end depresses a small automatic valve with a graduated port, which is connected to the train line. This causes an exhaust of train line pressure and applies the brakes. As soon as the train has slackened to a rate below the maximum speed the valve closes.

As the control instrument functions for a stop ramp, this reduces air pressure in a small pipe connection from the bottom of the control cylinder to a small cylinder in the speed control mechanism; a piston in the small cylinder sets out a cam between the disks and a latch drops into place, securely locking this cam, which is known as the medium speed cam. After the engineman has stopped for a red signal under this movement, he restores the positive stop valve and starts his train, but if he should attempt to run through a red block at a speed in excess of the prescribed medium speed, the governor applies the brakes by making a train line reduction. As soon as the train slackens, the little valve closes and the engine and train can proceed, but only under this limited speed. If another stop ramp is encountered in the interval it will again force the train to a stop and the cam mechanism will hold. As soon as the shoe engages a clear ramp, the cam mechanism



The Speed Control Apparatus Is Mounted Under the Cab

in the governor releases and the train can then operate up to a maximum speed.

Where it is necessary or desirable to operate a train over a stop ramp in order to take a siding, in a following movement on grades with tonnage signals, or for cross-over movements at an interlocking plant, the engineman must first place his train under a low speed control, of, say, 15 m. p. h., and at the time of engaging the ramp he must operate a release lever which will prevent the control from giving a stop. This manual action on the part of the engineman will set out a slow speed cam, and if the engineman should attempt to exceed this slow speed through the block, the governor will again function to make a brake application by reducing the train line pressure. It is claimed that in each of these operations the governor is so connected that it does not interfere with the fundamental part of the braking system; that it will cause no complications in installation or maintenance; and that it will operate with a minimum of attention, allowing the engineman to handle his train in accordance with rules and regulations, subject, of course, to the conditions set up by the train control mechanism.

As the governor functions at maximum speed, it will first notify the engineman (and in this way act as a speed indicator) that he is up to that high speed and unless he retards, the governor will apply his brakes. It will give him the same warning at 30 m. p. h., and it will give him a similar warning at 15 miles (or at whatever other medium and low speed limits may be selected by the railroad) when the shoe engages an energized ramp or a contact rail placed for the purpose at a siding, tunnel or bridge.

In order to comply with the government's specifications the positive stop valve was incorporated, which is simple and self-contained. When the control functions over a stop ramp this valve opens and requires a manual reset, and it has been necessary in the past for the engineman to descend to the ground to make this manual release. An electrical connection is provided through the speed control mechanism so that when the train comes to a stop or to a low speed, as may be determined, the engineman can push a button in the cab and reset the positive stop valve without leaving his seat; but no release is effected if the button is pushed at higher speeds. There is no way in which he can lock the positive stop valve and push the button at any time except when the train is stopped or practically stopped.

If, for any reason, this mechanism should get out of order, it is designed to fail on the safe side. The speed control and cab release mechanism can be applied to any type of steam or electric locomotive. It does not interfere in any way with the normal and safe operation of the Miller train control device as in service on the Chicago & Eastern Illinois, or in the handling of the locomotives on the road. It is claimed for this development that it has no complicated electrical circuits or delicate mechanism, and that the engine can be operated in non-controlled territory without cutting out any of this mechanism. If it is desired, the high speed feature may still be operative in non-train-control territory, as this is automatic in its operation whether the track is equipped with train control or not. The same inspectors and mechanics that inspect the air brakes or do the regular roundhouse work can maintain this mechanism as it has been designed and built with that object in view.

The introduction of electricity both for lighting and for power purposes has been of recent growth in India, and there are still hundreds of promising towns and commercial centers where electricity has not yet made its way. Various municipal bodies in the important trade centers and also the district towns have now come to regard the installation of electric plants for lighting and other purposes as a matter of first importance for the community resident in this area.

Theory of Direct Current Armature Windings

Useful Information for the Man Who Wants to Know What Lies Back of the Commutator

By K. C. Graham

THE railroad electrician is often called upon to make repairs which, although they may be only a temporary expedient, must be of such nature as to keep the apparatus in service for an indefinite length of time.

It shall be the purpose of this article to explain the method of locating and remedying the trouble and at the same time rigorously analyze such theory as is necessary to a complete understanding of the method pursued. One of the most frequent sources of operating troubles is

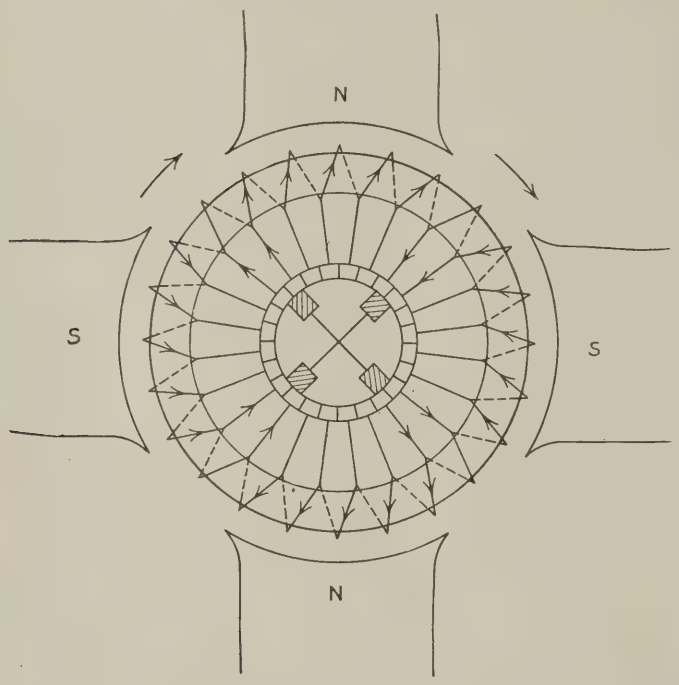


Fig. 1—Ring Wound Armature—Winding Consists of an Endless Spiral Connected at Equal Intervals to the Commutator

the armature of a direct current machine—therefore I shall consider this subject first.

Armature winding may be divided into two general classes, ring and drum.

Although ring windings are comparatively little used at the present time, a knowledge of their principles is necessary to enable us to more readily grasp the principles of the drum winding.

Fig. 1 shows a ring wound armature consisting of a laminated core on which is wound an endless spiral, connected at equal intervals, to a commutator. With clockwise direction of rotation, the generated e.m.f. is as shown by the arrow-heads and the current flows from the negative to the positive brushes *in* the armature and from the positive brushes to the negative *outside* the armature —i. e., in the external circuit. In this type of winding, the only conductors which cut lines of force are those on the outside of the laminated core—those on the inside acting merely as return conductors for the outer ones. These inner ones do not cut the lines because the flux from the poles follows the iron core to the poles of opposite polarity rather than taking the shorter air path. The reason for this is, of course, that the resistance of air to the passage of the lines is much greater than that of the iron.

For the above reason, the total weight of copper in the ring winding is about twice as great as the effective weight of copper. This fact, together with the great amount of labor involved in winding the armature, led to the development of the drum winding.

Drum windings may be divided into two classes, lap or parallel and wave or series. We shall speak of these two classes of windings as lap and wave. They take their respective names from the method of making connections to the commutator. For the present it will suffice to say that a lap winding may be recognized by virtue of the fact that the leads from the coil to the commutator come toward each other, or tend to overlap, as in Fig. 2 (a)—whereas, in a wave winding the leads spread as shown in Fig. 2 (b), making the path from *A* through the coil to *B* assume a wave form.

The distinctive feature of the drum winding is the fact that both conductors of the coil are effective in cutting lines of force.

Fig. 3 is an extended diagram of a four pole lap winding consisting of 24 conductors and, consequently, 12 coils. Conductor *1* is seen to be under a north pole, and conductor *6* is under a south pole. It may be seen

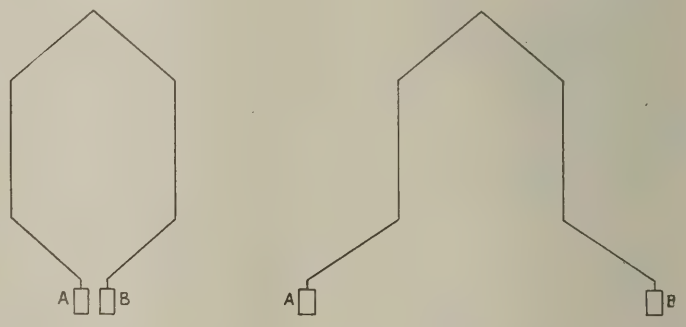


Fig. 2 (a) Fig. 2 (b)

Fig. 2 (a)—With Lap Winding the Leads from the Coil to the Commutator Come Towards Each Other

Fig. 2 (b)—With Wave Winding the Leads Spread Out Making the Path from A to B Assume a Wave Form

that the e.m.f.'s of these two conductors are in such a direction as to add, or in other words they are in the same direction when connected together to form a coil as in Fig. 3.

Tracing through the winding, and, at the same time paying particular attention to the arrow-heads, it is seen that there are four points on the commutator at which the e.m.f.'s in the two conductors connected to the same bar are opposed. These are the points at which the current must be collected or, in other words, these are the brush positions.

Fig. 4, which is a developed diagram of the winding shown in Fig. 3, illustrates this a little more clearly. The paths from brush to brush are as follows:

1-6-3-8-5-10
7-12-9-14-11-16
13-18-15-20-17-22
19-24-21-2-23-4

It is seen that in this case the number of paths is equal to the number of poles, and I might add, at this point, that in all simple lap windings there are as many paths as there are poles.

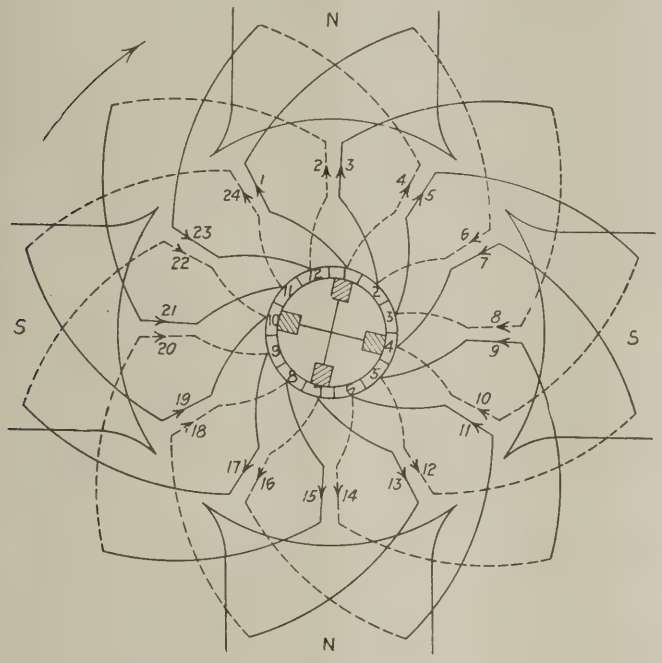


Fig. 3—An Extended Diagram of a Four-Pole Lap Winding Consisting of 24 Conductors or 12 Coils

Fig. 5 is an extended diagram of a four pole wave winding consisting of 15 coils, or 30 conductors, connected to a 15 bar commutator. Tracing through the winding we see that there are two points at which the e.m.f.'s in the two conductors connected to any one bar are opposed.

Fig. 6 is a developed diagram of this same winding. The paths through the windings are as follows:

21-28-5-12-19-26-3-10-17-24-1-8-15-22-29-6 to A.
14-7-30-23-16-9-2-25-18-11-4-27-20-13 to A.

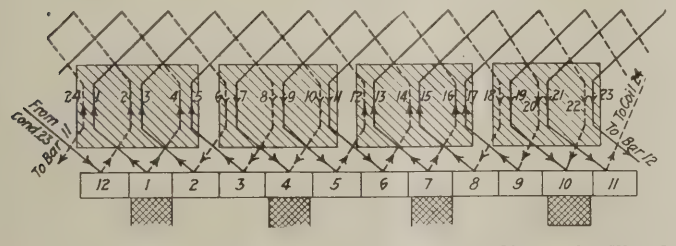


Fig. 4—A Developed Diagram of the Winding Shown in Fig. 3

In this case and in all single wave windings there are two paths regardless of the number of poles. However, current may be collected from the other end of the coil connected to the bar at brush *A*, namely, conductor 20, and the same thing applies, of course, to the coil connected to the bar at *B*.

The windings described above are single circuit windings, but there are two and three circuit windings which are seldom used in practice, and then only in special cases. The principle of such windings is exactly the same as the single circuit windings being, in effect simply two or three separate windings, as the case may be, on the same core.

One point that we have not touched upon is the effect of the number of commutator bars on the type of winding.

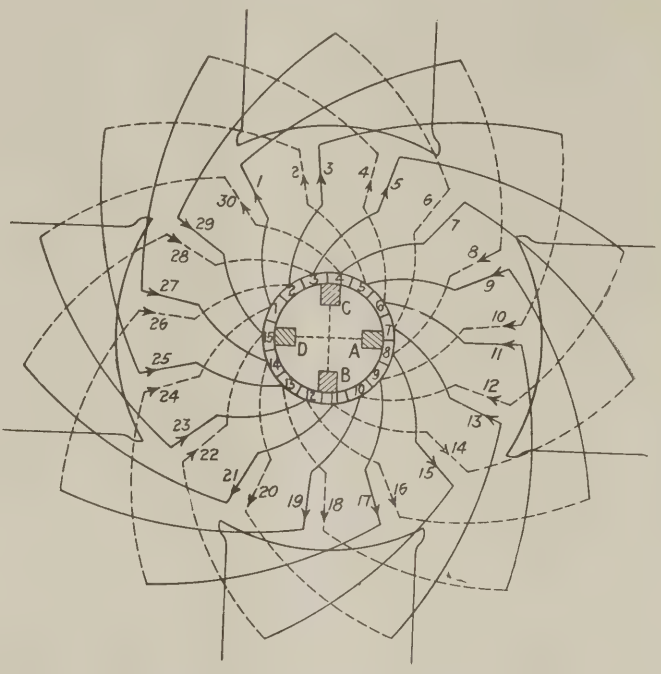


Fig. 5—An Extended Diagram of a Four-Pole Wave Winding Consisting of 30 Conductors or 15 Coils

In Fig. 3 there are 24 conductors and 12 commutator bars. But suppose there were 13 commutator bars and 26 conductors; tracing out such a winding we find that the only change is that the winding is unbalanced—i. e., some of the four paths will have more conductors than others; however, in a winding with numerous conductors the effect of this would be negligible. Therefore, we may conclude that we may construct a lap winding regardless of the number of commutator bars, whether odd or even.

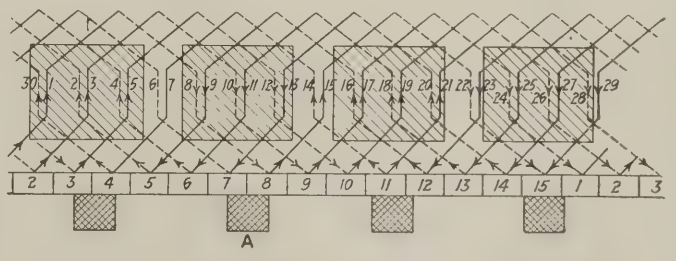


Fig. 6—A Developed Diagram of the Winding Shown in Fig. 5

Now, as to the wave winding, in Fig. 5 there are 30 conductors and 15 bars. Conductor *1* connects to bar *1* and conductor *8* (the other conductor which is connected to conductor *1* to form the complete coil) connects to bar *8*. We added seven to one to get eight—therefore adding seven to eight we have fifteen, which brings the end of the first complete circuit fifteen bars from the start, namely, bar fifteen, which is one bar to the left of the bar at which we started. Now suppose we had connected

conductor 8 to bar 9. The pitch would have been nine minus one or eight. Adding eight to nine gives seventeen. Counting seventeen from bar 1 we arrive at bar 2. In each case we arrive at a bar next to the start, or in other words, we slip backward or forward one bar each time we encircle the armature; eventually slipping so far that we are back to the start and each and every conductor on the armature has become part of the complete circuit just as the spirals on the ring winding of Fig. 1

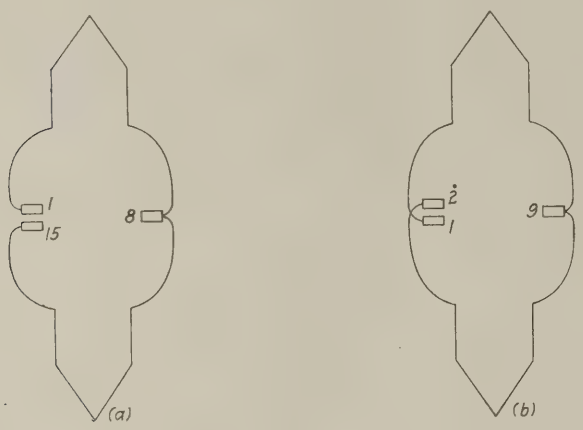


Fig. 7 (a)—Retrogressive Wave Winding
Fig. 7 (b)—Progressive Wave Winding

are a part of the complete spiral which encircles the core. The type of wave winding in which the finish of each circuit is a bar to the left of the start is called a retrogressive wave winding and the second type, in which the finish comes a bar to the right, is called a progressive wave winding—retrogressive meaning backward and progressive meaning forward. Both types are met with in

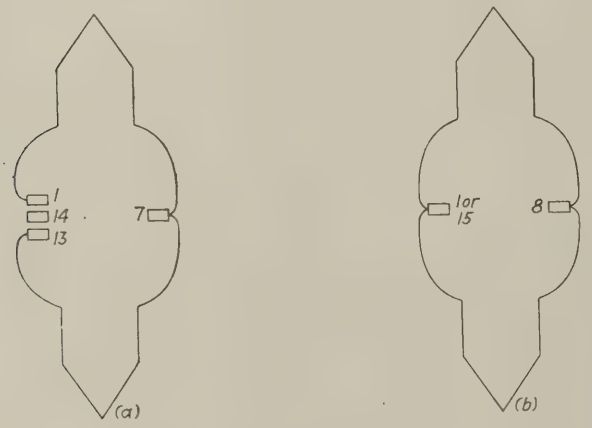


Fig. 8 (a)—Type of Coil Required For a Two Circuit Wave Winding With a Commutator of 14 Bars
Fig. 8 (b)—This Type of Coil Would Produce a Seven Circuit Winding on a 15 Bar Commutator

actice. Figs. 7 (a) and (b) illustrate these two types very clearly.

Now suppose there had been fourteen commutator bars. If we had connected coil 1 between bars 1 and 7 and the other coil in this circuit from 7 to 13, this would bring us two bars from the start as in Fig. 8 (a). Laying out this winding we proceed as follows: 1-7, 7-13, 13-5, 5-11, 11-3, 3-9, 9-1.

This brings us back to the bar at which we started, although we have only traced through one-half the conductors on the armature, and if we were to start at bar 2 we would trace through the other half of the winding, ending up at bar 2, thus having made two separate and distinct complete circuits of the armature. In other words, we would have a two-circuit wave winding.

If we connect coil 1 to bars 1 and 8, the finish of the first turn around the armature would be fifteen bars from the start, or in bar 1 as shown in Fig. 8 (b). Here we would have seven circuits in the armature, each circuit consisting of two coils.

From this we may conclude that, regardless of the manner in which we may connect the leads, it is impossible to obtain a single circuit four pole simple wave winding with an even number of commutator bars.

Now a word as to the method of determining the commutator pitch for four pole wave wound armatures. In the fifteen bar commutator we connected from 1 to 8 or from 1 to 9, giving pitches of eight minus one, or seven and nine minus one, or eight respectively. A rule governing the choice of commutator pitch for four pole armaminus one) divided by two, or

$$P = \frac{n \pm 1}{2}.$$ Thus with 15 bars $\frac{15 \pm 1}{2}$

$= \frac{14}{2}$ or $\frac{16}{2} = 7$ or 8, and the throw would be 1 plus 7 = 8 or bar 1 and bar 8; or it could be 1 plus 8 = 9 or bar 1 and bar 9.

Thus far we have only considered four pole armatures,

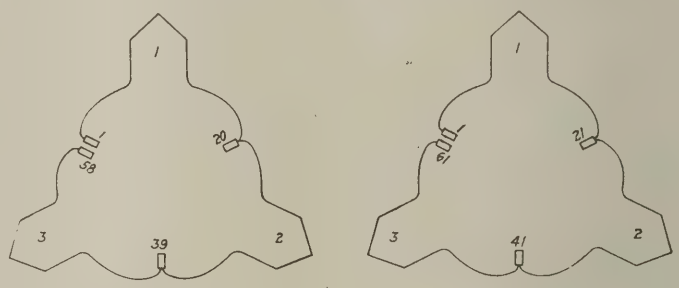


Fig. 9 (a) Fig. 9 (b)

Fig. 9 (a)—Winding Arrangement of a Six-Pole Armature with 58 Commutator Bars
Fig. 9 (b)—A Similar Winding to Fig. 9 (a) Except That 61 Commutator Bars Are Used

which type is more numerous than two, or six pole machines. However, the other types are frequently met with in practice, and it would be well to consider them further.

Two pole armatures are invariably lap wound, and as in the case of the four pole single lap winding the number of commutator bars is immaterial; in fact, this applies to single lap windings for any number of poles.

Six pole wave windings may be made with an even or an uneven number of bars, but the number of bars cannot be chosen indiscriminately.

Fig. 9 (a) shows the winding arrangement of a six pole armature with 58 commutator bars and Fig. 9 (b) one with 61 bars. Only one complete turn around the armature is shown in each case, but this is enough to illustrate the principle involved. The rule for determining the commutator pitch is rather complicated; in fact, no simple hard and fast rule will apply in all cases, but a few illustrations will serve to show the method of procedure.

In the case of the 58 bar machine, subtracting 1 from 58 gives 57, which, divided by 3, gives 19, as the commutator pitch. Laying out this circuit we have 1-20, 20-39, 39-58, which brings us one bar from the start, and will, consequently, produce a single circuit wave winding. Proceeding with the 61 bar machine, in exactly the same way we have 1-21, 21-41, 41-61, which proves out the same as the 58 bar machine even though 58 is even and 61 is odd. However, it will be noted that when we subtracted 1 in each case the resulting number was exactly divisible by 3. As a general method of procedure it may be said that if the number of bars is exactly divisible by three a single circuit 6 pole wave winding cannot be obtained without dropping one or more bars. Thus a 60 bar commutator would not do unless we dropped two bars. We must add to or subtract from the number of bars the least number that will give a result that is divisible by three and the result obtained by dividing this number by three will be the commutator pitch; thus in the case of a 62 bar machine we add 1 to 62, which gives 63; dividing this by three gives 21 as the pitch; laying out the winding we have 1-22, 22-43, 43-64; counting 64 from the start brings us to bar 2, which is next to the bar from which we started, and which consequently produces a single circuit wave winding. In all cases the winding should be laid out as above as a check on the result obtained.

Eight, ten or, in fact, any number of pole machines will present no difficulties if the above methods are followed.

Gas-Electric Locomotive

A NEW 40-ton gasoline-electric locomotive embodying marked improvements in design and construction over previous types was completed recently by the General Electric Company. A simple throttling controller without resistances makes it possible to use the full power of the engine at all speeds.

Comprehensive operating and maintenance tests have been given the new locomotive which show it to be more economical in operation than mechanical drive locomotives of the auto bus type. Nine months operating results indicate that the maintenance costs will also be very low.

The locomotive is expected to find wide application on steam road branch lines for freight and passenger service, switching, haulage, etc. It is equipped with four GE-820, 500-volt, 60 hp. mine type motors operating from a 100 kw. generator direct connected to a Sterling six cylinder Dolphin engine. The control is extremely simple, due to the flexibility of the generator. The generator has a shunt field excited from a direct driven exciter and a series differential field. The proportions of these fields are such that the result is practically a constant power generator. There are no starting resistances nor field regulating resistances, and the speed of the locomotive is regulated directly by a throttle lever connected to the gasoline engine.

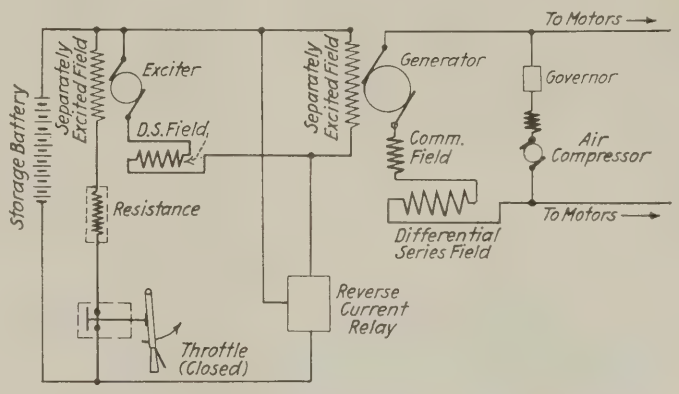


Diagram of Automatic Electrical Control for Gas-Electric Locomotive

The maximum power may be obtained from the gasoline engine for starting the train, due to the fact that the engine may be run practically at full speed. The generator characteristics are such that under this condition of starting, where a heavy torque is required at low speed, the heavy current drawn by the motors, automatically reduces the voltage on the generator. As the train accelerates and the current required becomes less, the voltage on the generator gradually builds up until there is full voltage when the locomotive will be running full speed. The control consists of a drum controller having 2 points, one for series connection of the motors and the other for parallel connection of the motors in addition to the regular reverse drum. The controller therefore, merely serves as a set-up switch. On the throttle of the engine is a contact which when the throttle is thrown to the idling position,

Locomotive Hauling a 9-Car Train Weighing 353 Tons

takes off the excitation from the exciter. As shown in Figure 1, the exciter field is energized by a storage battery. This storage battery is kept automatically charged when the exciter is energized. The air compressor for furnishing air for the air brakes, is connected across the main generator so as to keep up air pressure while the locomotive is running. Double end control is used.

The running gear consists of two, four-wheel, swiveling, arch bar trucks with floating bolster. The center pin load is carried on a nest of helical gears. Journal boxes are of the MCB collar type. Wheels are 33 inch rolled steel wheels with MCB contour.

G-E straight and automatic air brake equipment is furnished, including a 600-volt motor-driven compressor. An auxiliary ratchet type hand brake is also furnished.

The MCB long shank couplers with draft gear are of standard type. The center of the coupling is located 34½ in. above the rail. The cab is of steeple type construction. The radiator is of the fin tube type mounted on cab roof with forced circulation from pump on the engine. A drainage tank is provided for emptying the cooling system and the locomotive has a 100 gallon capacity fuel tank.

Interior View of Locomotive

Two incandescent headlights with parabolic reflectors are mounted on each end of the cab.

The principal dimensions are:

Gage	56½ in.
Rigid wheel base	7 ft.
Truck centers	17 ft. 6 in.
Wheel diameter	33 in.
Width	9 ft. 6 in.
Length inside knuckles	24 ft. 7 in.
Overall height	14 ft. 6 in.

This locomotive, according to tests while in actual service, showed a consumption of 37 gallons of gasoline per 8-hour working day at 4.5 kw.-hr. per gallon, 65 watt hours per ton mile and 166 kw.-hr. per 8-hour day. About 3 quarts of oil are necessary daily. The locomotive maintenance cost has been about 5 cents a mile.

The capacity of the locomotive is shown by the following tests during service which do not represent the maximum but rather the general average conditions:

The working schedule described is based upon 8 hours' duration, and does not indicate the total number of hours the locomotive is available for service each day.

Estimated locomotive mileage in 8 hours' switching service—22 miles. Estimated average weight loaded train including locomotive—160 tons. Average number of cars per loaded trip—3 cars of 40 tons each. Approximate balancing speed on level tangent track (160 tons)—7 m.p.hr. Average length of shift with average train—1,200 to 1,500 ft. Average speed per shift while in motion—5.0 m.p.h. Locomotive miles per 8-hour day (light)—8.0 Locomotive balancing speed running light—20.0 m.p.hr. Locomotive ton miles per day 8 hours (22 m.)—880. Trailing ton miles per 8 hours—1,680. Total gross ton miles per 8-hour day—2,560.

While this locomotive is primarily designed as an independent operating unit, it can be so designed as to operate with a trolley or third rail when in an electrified territory.

Electric Outpulls Steam Locomotive

In conjunction with the tests of the Paris-Orleans locomotive, recently made, tests were also made on one of the electric locomotives built for the Mexican State Railways. The Mexican locomotives were described in the *Railway Electrical Engineer* for December, page 403. A steam locomotive was used to push the electric while power was returned to the line by regeneration. At a speed of 14 miles an hour, 1,800 hp. has returned to the system.

A tug of war exhibition was also made with the steam and electric locomotives. The steam locomotive was a Mikado equipped with all modern improvements, including a booster. The weight on drivers of the two locomotives was the same within the limits of the scales; i. e., 306,000 lb. This included the booster in the case of the steam locomotive. There is, however, a difference in the rated tractive efforts of the two locomotives. The rating of the electric locomotive based on 3.33 adhesion factor is approximately 92,000 lb. The rating of the steam locomotive is 78,100 lb. The two locomotives were coupled together and at a given signal applied power in opposite directions. The electric held the steam locomotive and then pulled it backwards. From readings taken, a fairly accurate calculation of the draw-bar pull was made as follows:

New York Central Mikado and Mexican State Electric Locomotives in Pulling Contest

Balanced draw-bar pull at standstill, 86,000 lb.

Electric hauling Mikado backwards, 94,000 lb. approx.

Other tests were made showing that the steam locomotive could be allowed to reach a low speed before power was applied by the electric, and given this advantage, the electric locomotive was able to stop and haul the steam engine backward. In all tests the rail was well sanded.

G. R. S. Train Control Demonstrated on C. & N.W.

Actual Service Test Shows Practicability of Intermittent Tapered Speed Control and Stop Indications

THE Chicago & North Western demonstrated the General Railway Signal Company's system of intermittent inductive tapered train control on October 13, between West Chicago, Ill. and Forris (Elgin). A special train consisting of an Atlantic type locomotive, a business car and a parlor observation car left Chicago at 9 a. m., the test being completed at 3.00 p. m. Fifteen railroads were represented by signal, mechanical and general officers, there being a total of 41 present.

The territory on which this device is installed is not a portion of the line designated in the Interstate Commerce

Making Low Speed Tests Over Pair of Track Inductors

Commission's order and this installation was made primarily for test purposes. From West Chicago to Wayne, there is five miles of double track, the balance being single track. The double track is equipped with Model 2A, direct-current signals located on bridges and the single track is equipped with the absolute permissive block system, Model 2A, direct-current signals being mounted on the masts in the usual manner.

The installation is of special interest due to the nature of the track and the varied classes of traffic which operate over it. Fixed limited speed is imposed at certain locations, as approaching the end of double track and interlocking parts, *i.e.,* certain fixed speed limitations are in effect which are enforced through the use of pairs of inductors constructed without windings. The speed control scheme generally uses three pairs of inductors governing the approach to stop signals which force the deceleration of a train to insure a safe stop. Speed is so tapered as to handle the trains as they would be handled manually, automatic braking being used only when speed limits are exceeded.

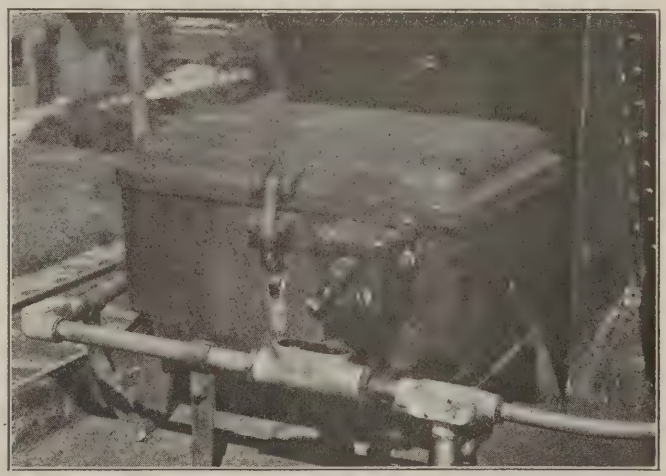
There is an interlocking plant a short distance from the West Chicago station from which it has been customary, under certain traffic conditions, to advance trains to the station on "Call-on" signals. The limited speed indicated by the "Call-on" signals is now enforced by the application of pairs of inductors suitably placed between the interlocking plant and West Chicago station.

The speed control and receiving apparatus for freight and passenger locomotives is identical except for the timing of the time element contactor. Locomotives that are, under certain circumstances, used in both passenger and freight service are equipped with time element contactors that may be automatically adjusted for either class of service. At present two passenger and two freight locomotives are equipped with receiver apparatus and mechanism for operating engineer's brake valve. A number of tests were made to demonstrate the operation of the system for both speed control and train stop features. Detailed description of the General Railway Signal Company's train control system was published on page 95, March, 1922 and on page 179, June, 1923 of the *Railway Electrical Engineer.*

Actual Train Operation Tests Made

On leaving West Chicago, the special test train followed a scheduled milk train, the engine man of the special train being instructed to pass signals at "caution" or "danger" in an attempt to close up on the milk train. While the milk train was in the block signal 913, *i.e.,* at the station at Wayne, signal 913 was at "stop," and signal 911, at "caution." Under these conditions the special train, in approaching signal 913 at a speed of 55 m.p.h., received a brake application at the first pair of inductors after passing signal 911. This automatic application of the brakes brought the train to a stop in approximately 3,300 ft. with the locomotive and one-half the length of the first car past the signal.

The special train then followed the milk train west from Wayne on the single track. Signal 919, in the caution



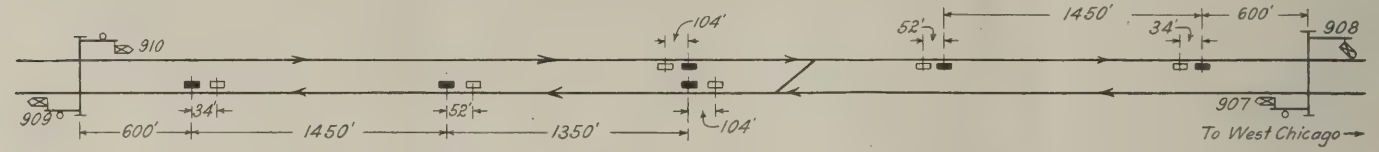
Relays and Timing Element Are Housed in a Cast-Iron Box on the Tender

position, was passed at a speed of 40 m.p.h. and an automatic brake application was received at the second pair of inductors bringing the train to a stop at a point about 500 ft. before the signal was reached.

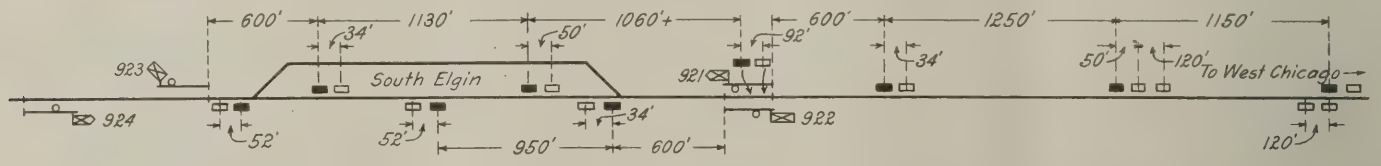
The train was then backed to West Chicago and turned. It then backed to Wayne where it was crossed over and headed east on the eastbound track. While a gravel train was in the block the special train attempted to pass signal 910 at 45 m.p.h., but was stopped automatically.

On the next test, signal 908 was disconnected and placed at stop purposely, thus causing signal 913 to assume the "caution" position. The train was again backed to Wayne and an effort was made, on again proceeding eastbound, to pass signal 910 in the caution position at maximum speed to see if the speed restriction would be enforced automatically. In this test, a brake application was received at the intermediate speed inductors and the train was stopped within 1,400 ft.

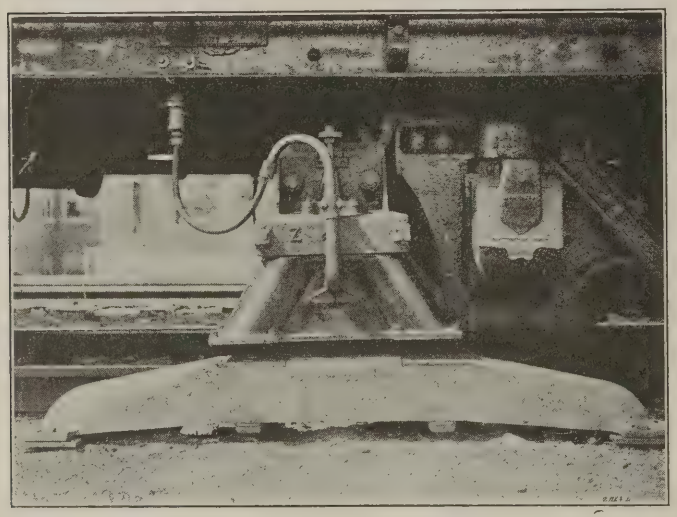
With signal 908 at "stop" and 910 at "caution" an attempt was next made to operate the train at a low speed over the first two sets of speed control inductors and to pass the third set near signal 908 at a low speed so as to disregard the signal indication. However, the apparatus functioned as intended, the train being stopped automatically within 600 ft. when traveling at 23 m.p.h. although working steam until actually stopped. In repetition of this test at 25 m.p.h. the train was stopped at the signal. All of the foregoing tests were made with a brake pipe pressure of 70 lb. instead of 90 lb. which accounted for the engine and part of one car overrunning the signal in one test.



Track and Signal Plan Showing Location of Track Inductors on Typical Double Track Layout



Layout on Single Track. Black Rectangles Represent Energized Inductors; Open Rectangles, Unwound Inductors



Receiving Element on Tender Truck Standing Over a Track Inductor

The system was not installed with the idea of stopping light trains with low brake pipe pressure and with throttle open short of the signal in case of an automatic application of the brakes. Should a railroad require an installation to give protection under such conditions it is provided by installing the control points further in the rear of the signal with which they are associated.

Tests were made next to determine the minimum speed at which an effective impulse could be received by the equipment from a track inductor. The low-speed pair of track inductors used for this test were 34 ft. apart, and the following results were obtained from timing the passing of the engine over the inductor with a stop watch.

It will be noted in the table below that no impulse was received at a speed of approximately 2.4 miles per hour. The engine used in this test, however, was one of the first ones equipped in which the receiver was placed between the journal box and springs. Later engines are now being equipped having the receiver overhung and outside of the journal box which, it is claimed, results in more powerful impulse, and had the receiver been mounted in this way an impulse would have been received at speeds lower than those shown in the table below.

	Speed M. P. H.	
1.	2.41	No impulse received from either inductors
2.	2.79	Impulse received from first inductor only
3.	2.88	Impulse received from first inductor only
4.	3.22	Impulse received from first inductor only
5.	3.86	Impulse received from both inductors
6.	4.28	Impulse received from both inductors

On the final test with signal 908 at stop and 910 at caution and the train running past signal 910 at 57 m.p.h., the automatic brake application was received at the high speed inductors which stopped the train just short of signal 908. Steam was worked until the train was stopped.

A Typical Country Station on the South African Railways

THE INTERCHANGE

A Handy Battery Elevator Truck

In battery rooms the equipment provided to eliminate the lifting of batteries is bound to promote efficiency. In the storage battery room in the 47th street yards, Chicago, of the Chicago & Western Indiana, a truck equipped with an elevating platform raised by a hand windlass is used

Showing the Truck in the Lowered and Raised Positions

to set batteries up on trucks, on the washing bench or on the larger shelves for charging and storing.

The movable platform is supported and slides up and down in the channel iron side frames. A cable attached to the platform passes over the pulley at the top and down again around the drum which is driven by the smaller gear on the hand crank shaft. The device has an automatic band brake that holds the platform in any position or can be used to lower the loaded platform gradually. The upright frame is hinged to permit the truck being taken through low doors.

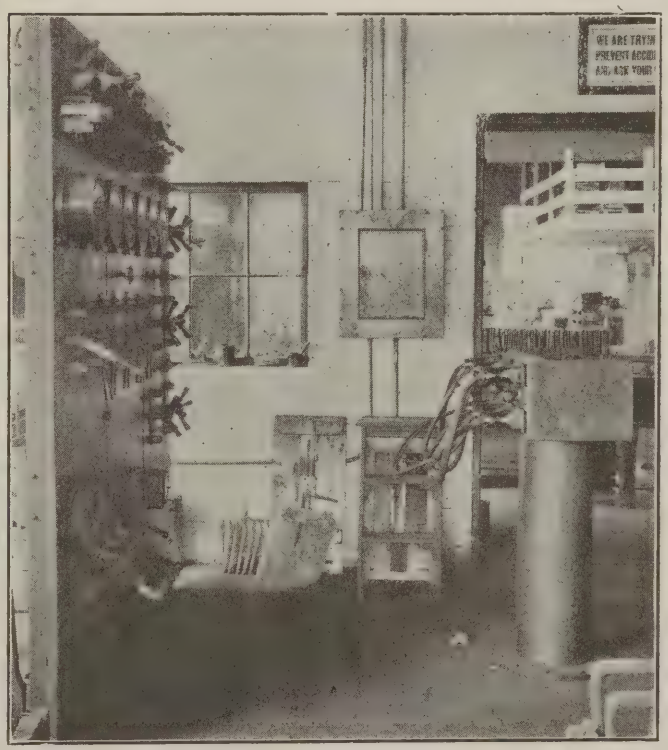
A Compact Distribution Panel for Battery Charging

A convenient and compact form of distribution panel for battery charging circuits which can be made up in the shop is shown in the accompanying illustrations. Two such panels are used for yard charging by the Soo Line.

The panel is made up of a number of Crouse-Hinds B R 100 receptacles mounted close together in three tiers with nine units in each tier in a rectangular iron frame. A sheet steel cover, not shown, covers the top and back of the frame and the frame is mounted on a hollow iron pillar bolted or lagged to the floor, six feet in front of the charging control panels.

There are six charging control panels and the circuits from these panels are carried under the floor and up through the iron pillar to six of the receptacles. The remainder of the receptacles are connected to charging lines in the yard.

Each charging line in the yard is fitted with several outlets connected in series and these outlets are normally short circuited with a short circuiting plug. A 125-volt circuit is used for charging and the resistances on the control panels make it possible to charge a single battery or to charge two or three in series. Each receptacle in the cen-

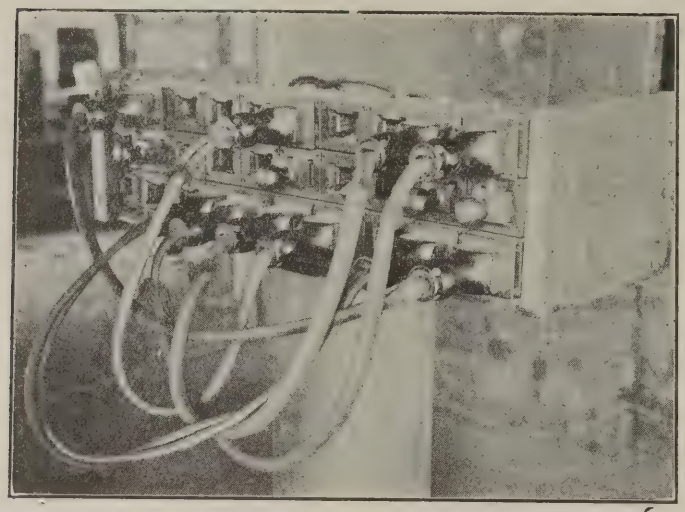


General View of Switchboard Room

ter row is connected in series with the one above it and when only one circuit is being controlled by a rheostat the circuit is closed by inserting a plug (several of which are shown in the illustration). If two lines are to be connected in series the plug is withdrawn and the other circuit plugged in.

The first step in charging batteries is to pull the short circuiting plugs in the yards and replace them with the

plugs on the charging leads to the cars. Then the proper receptacle on the distribution panel is connected to one of the circuits from the control board by means of a short

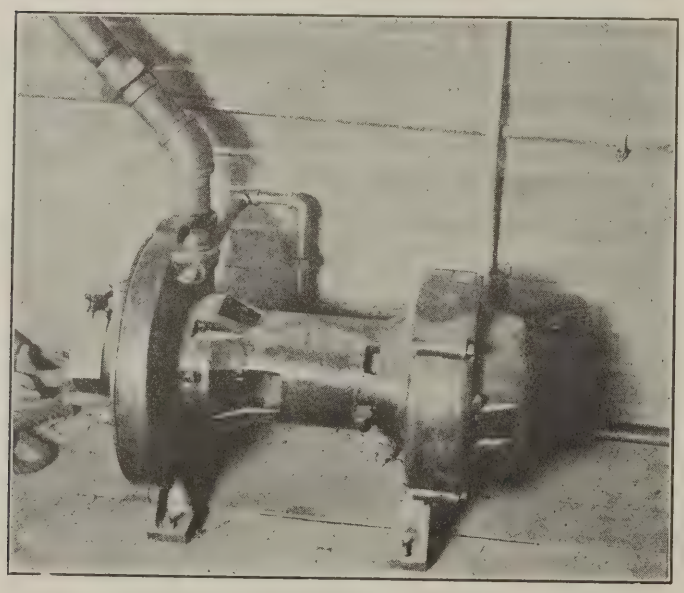


Close-Up View of Distribution Panel

cable with a plug on each end. Finally the current is switched on at the control panel and is adjusted to the proper value by a carbon pile rheostat.

Emergency Lights For Power House

Electric power for the Union Pacific shops at Omaha is developed during the greater part of the year by the company's own steam plant. A connection is also maintained with the local power company for emergencies and in the summer when there is no demand for exhaust steam for heating, the

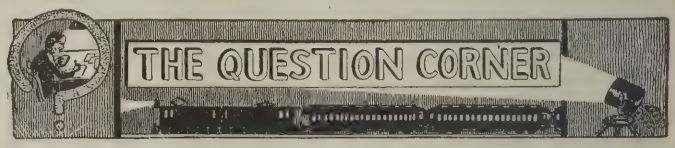


Locomotive Headlight Set on Platform In Boiler Room

steam driven units are shut down and power is taken from the power company service. This is usually done only at night and there is always steam on the boilers.

At rare intervals the purchased power supply fails. It is then necessary to start the steam units immediately. This emergency calls for lights which are provided by a Pyle National Type E 500-watt headlight set.

The valve controlling the headlight turbine is placed alongside the door leading from the engine room to the boiler room on the boiler room side where it can be reached easily by a man from either room, and a Western Electric Utility floodlight containing a 150-watt lamp is mounted over the door on each side of the wall. A third unit is mounted on the wall at one end of the switchboard and in this way light is provided for getting the power house machinery started.



Answers to Questions

1. *If a circuit contains a neglibible resistance and has an inductance of .4 henry, what voltage is necessary to cause 5 amperes to flow? The frequency is 60 cycles per second.*

2. *If an alternating current flowing through a resistance reaches a maximum value of 300 amperes during every alternation, what value of continuous current will develop the same amount of heat when sent through the same resistance?*

3. *What is this value called with reference to the alternating current?—A. L. B.*

Alternating Current Queries

1. The first question may be answered by using the formula for alternating currents.

$$E = I \times \sqrt{R^2 + (2\pi fL)^2}$$

Where E = the voltage
I = the current
R = resistance
f = frequency
L = inductance

Substituting the known values the formula is as follows:

$$E = 5 \times \sqrt{0^2 + (2\pi \times 60 \times .4)^2}$$
$$= 5 \times \sqrt{(2\pi \times 60 \times .4)^2}$$
$$= 5 \times 2\pi \times 60 \times .4$$
$$= 5 \times 6.28 \times 60 \times .4$$
$$= 753.6 \text{ volts answer.}$$

2. The second question involves a little knowledge of the behavior of alternating current. The maximum value which any alternating current reaches is always higher than that indicated by an alternating current ammeter through which it may be passing. The value recorded by the ammeter is only .707 of the maximum.

$$300 \times .707 = 212.1 \text{ amperes}$$

3. The value mentioned in question No. 2 is called the *effective* or *virtual* value. In other words, a direct current of 212.1 amperes would have the same heating effect as an alternating current whose maximum was 300 amps.

Questions for January

1. *Why do the inside or back cells of two compartment train lighting batteries become pitted and leaky more than the front cells?*

2. *What would cause the negative plates of a lead storage battery to turn red or a reddish brown?*

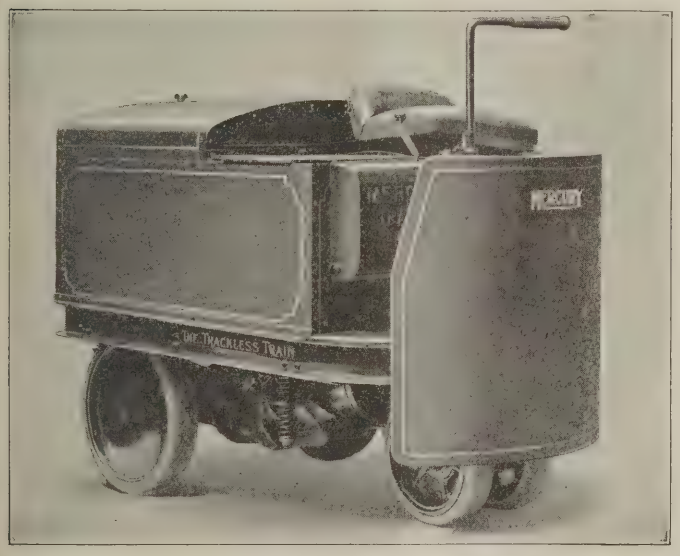
3. *Why is it that a battery once overheated and overdischarged cannot be brought up to full capacity until the plates are taken out, washed and recharged with new acid?*

NEW DEVICES

Unique Drive in New Tractor

An internal gear drive for industrial tractors has been perfected by the Mercury Manufacturing Company, Chicago, and after three years of experimental operation, a new model—the Type H tractor—has been placed on the market in which this drive mechanism has been incorporated.

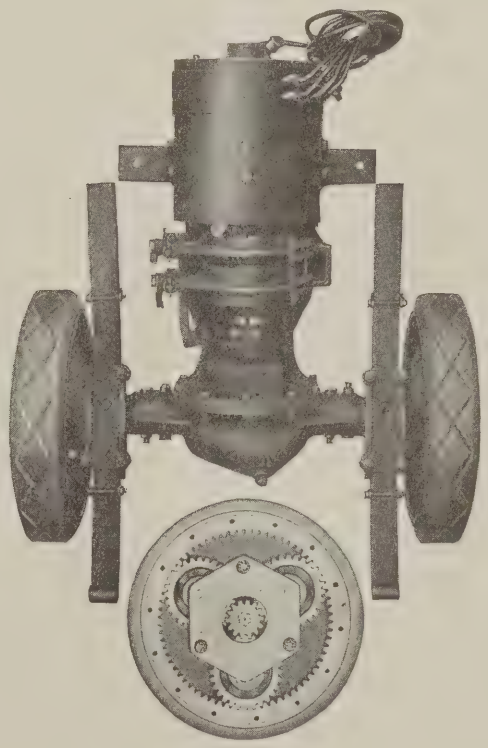
The most important advantage claimed by the manufacturer, on the basis of elaborate tests, is an increase of 25 to 35 per cent in mechanical efficiency, compared with the Type L tractor of this company, a worm drive model.



The Type-H Mercury Tractor

These tests showed, for example that at a 200-lb. draw-bar pull, the new model was developing an efficiency, indicated by speed and current consumption, 23 per cent greater than the Type L; at a 600-lb. draw-bar pull, 28 per cent; at 800 lb. drawbar pull, 40 per cent, etc. This increase in efficiency means an ability to run longer on one charge, to handle heavier loads during the same length of time, or to reduce the amount of the charge without reducing the reserve capacity of the batteries.

According to reports from the manufacturer five tractors of the new internal gear drive which have been in experimental service for the last two years, have demonstrated high efficiency in maintenance as well as in operation. Thus far it has been unnecessary to replace any parts of the drive mechanism. The salient features of the new drive are the balanced arrangement of the driving gears within the wheels; the method used to position these gears in relation to one another; and the provision for an oil and dust-tight enclosure for every moving part. The power plant comprising the motor, motor hanger, rear axle housing, rear wheels, rear springs and all driving gears, is assembled in a single unit which may be



The Power Plant and a View of the Internal Gear

readily detached from the frame. The sequence of operation in this drive unit is as follows: The motor, joined to a pinion through a self-aligning spring coupler, drives a bevel gear contained in the axle housing. This gear in turn drives the axle pinions to each rear wheel. The axle pinions transmit the power through three idler gears to a large ring gear mounted on the inner circumference of the drive wheels.

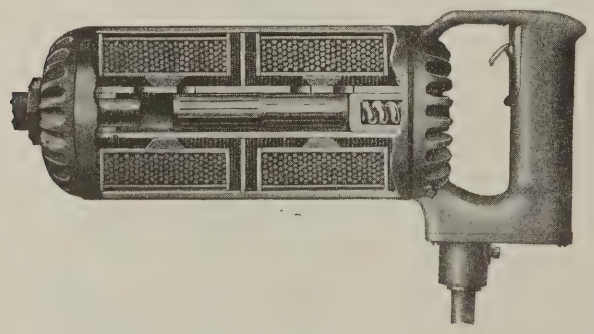
The motor is a high-speed, series-wound automotive

type, its characteristics being adapted to the gear drive and battery assemblies used. The coupling beween the motor and the driving pinion comprises four coil springs which cushion the initial starting torque, thereby allowing greater freedom of alinement, and eliminating much of the shock attending the operation of the machine. The frame, controller, safety features, wheel arrangement, etc., follow the lines which have been developed and used in the earlier designs of this company's equipment.

An Electric Hammer

A portable tool known as the Syntron electric hammer is being manufactured by the National Electric Manufacturing Company, Pittsburgh, Pa. It is designed to run on 60-cycle current and at this frequency strikes 3,600 blows per minute. It is suitable for drilling through masonry walls, drilling holes for expansion bolts, chipping castings, light riveting and assembly work, chipping and cracking stone, calking pipe, tank plates and so forth. A similar tool designed for 25 cycles which will strike 1,500 blows a minute can be used for heavier riveting. The hammer proper consists of two windings which are energized alternately to impart a reciprocating movement to a movable core or piston, which is the only moving part. In its forward stroke, the piston strikes a tool, which may be a drill, chisel, rivet set or the like. In its backward stroke the piston strikes an elastic bumper in which it stores its kinetic energy until it is moved forward again. The energy stored in the bumper is then returned to the piston on the forward stroke.

To operate the hammer, alternating current is supplied to the two windings to energize them alternately so as to



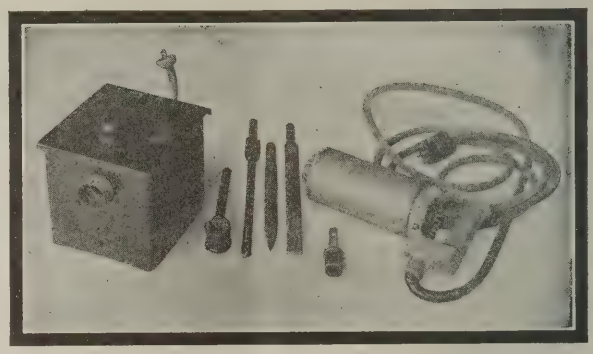
The Syntron Electric Hammer Showing the Coils and Piston Slide in Section

impart a reciprocating movement to the piston, which will move in synchronism with the frequency of the alternating current supplied to the windings. The current alone produces the operating forces to move the piston. No mechanical devices are used.

The hammer is rugged in construction and aside from an occasional oiling of the piston, needs no attention. The piston is made of special hardened steel and will last indefinitely. A trigger switch on the handle of the hammer starts and stops the hammer.

The hammer meets the need of a portable hammer drill that can be carried from job to job. It can be connected to any lamp socket and is then ready for work.

The ruggedness of the tool is shown by a test which was made on one of them. The hammer was placed in a position approximating that of actual service. A blunt steel bit was inserted in the hammer and the tool was pressed down on a block of steel with a weight representing the pressure that would be applied by an operator. The current was applied and the apparatus run in this condition for 948 consecutive hours without adjustment of any kind. When the tool was stopped, it was in a condition to be operated further and was cool enough to be held by the handle. The only noticeable wear occurred on the heads of the piston and the tool where they struck each other. They showed a slight lapping, but not one that would affect the efficiency of the hammer. It is estimated that



The Hammer Complete With Cord, Plug, Tools and Control Box. The Control Box Contains No Moving Parts

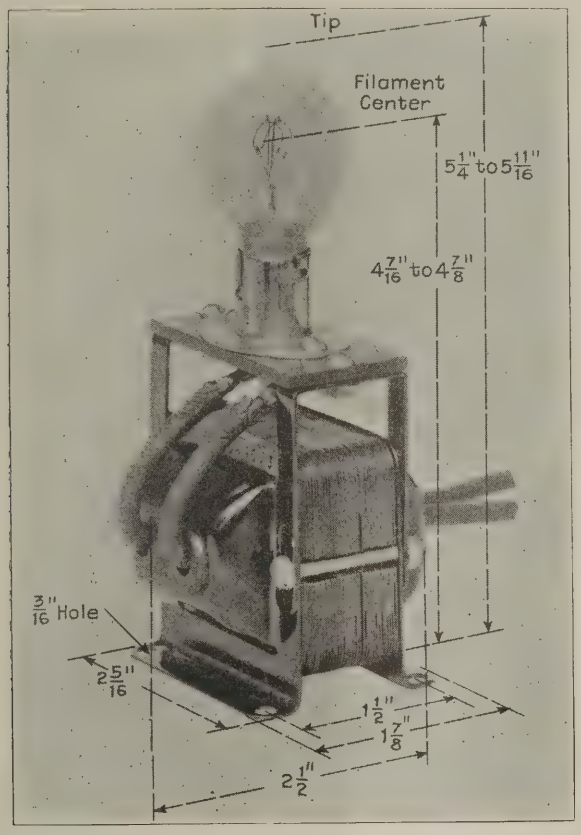
this test run is equivalent to about four years of ordinary service.

The hammer is at present available in three sizes, one weighing 10 pounds, the second weighing 17 pounds and the third weighing 24 pounds. All sizes are available for 110 or 220 volts and any frequency. The power consumption of the 17-pound hammer is 300 watts. Two carrying kits are supplied to hold the hammer and a control box, together with a 50 ft. extension cord and a complete assortment of drills, chisels and stone points.

Transformer for Switch Lantern

The advantage of electricity over oil for the illumination of railway signals has long been recognized, but little attention has been given to electric lighting of lanterns on hand-thrown switch-stands. This is probably due to the inability to distribute cheap and reliable commercial power. Installations of the a. c. floating battery system make possible the electric lighting of all switch lanterns in the territory served by the system. The filaments of 110-volt lamps are too fragile for switch lighting service because the switch stands are usually mounted on long ties and the shocks and vibration are severe. Hence low voltage lamps should be used in order to obtain a rugged filament. In order to meet this situation the General Electric Company has recently placed on the market a switch lighting transformer, equipped with a standard 10-volt lamp, as shown in the accompanying illustration. The transformer is designed to operate on alternating current of any frequency from 25 to 140 cycles. It has a 115-volt primary and 10-volt secondary winding. The lamp receptacle is mounted on an insulating base. Means are provided for a vertical adjustment of 7/16 in. and a horizontal adjustment in two directions of 1/32 in. The lamp is the S-11 bulb, C-3, filament, single contact bayonet base ¼ amp. 10-volt, shown on A. R. A. plan 1,544, part 15,442. This

transformer can be installed in an existing oil lantern of either the side door or top door type. If it is not convenient to drill the bottom of the lantern for holding down screws, the transformer can be mounted on a piece of



The New Transformer, Together With a Lamp Mounting, May Be Placed in an Old Oil Lantern Body

sheet steel the same horizontal dimensions as the oil fount, and set in the lantern. The primary leads should be brought into the lantern through a porcelain entrance bushing.

An A. C. Motor That Corrects Power-Factor

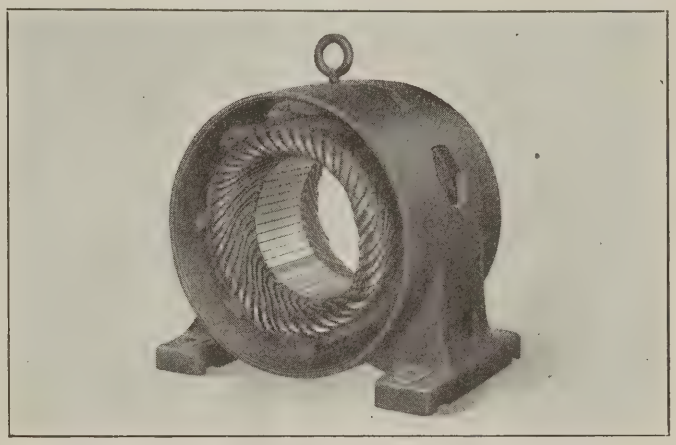
The Wagner Electric Corporation has developed a radically new type of constant-speed alternating-current motor, designated as the Fynn-Weichsel motor, which has many desirable characteristics.

The motor starts as a slip-ring induction motor, having starting torque characteristics much more favorable than the usual squirrel-cage motor; that is, it will develop 150 per cent torque with a starting current of from 150 to 200 per cent of full load current. After the motor attains synchronous speed which it will do under 150 per cent load, it becomes a self-excited synchronous induction motor.

With appropriate windings, the motor can be made to operate at unity power-factor, or with a definitely leading current to compensate for lagging current taken by other motors on the same line.

As a synchronous induction motor, it will carry 150 per cent load without falling out of step. Above this value it drops into induction motor characteristics and continues to run as a slip-ring motor, to the breakdown point of approximately 300 per cent load before it stops. In this way the motor combines the favorable and desirable characteristics of both the slip-ring induction motor and the synchronous motor without any of their most objectionable features. It may be designed for a wide range of characteristics with respect to power-factor at various loads.

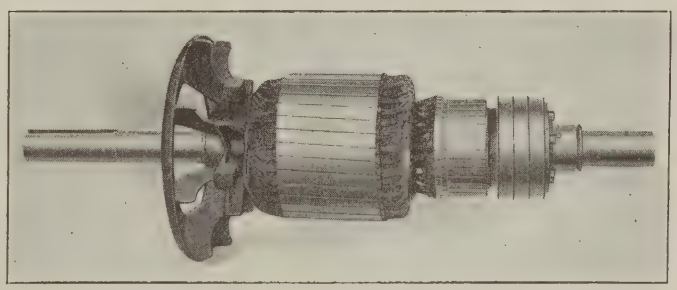
Loading the motor beyond the limits of synchronous speed operation simply establishes slip sufficient to carry the load as an induction motor. There is always a synchronizing tendency that reduces slip, and when the load decreases to a point below 150 per cent of full load, it



The Stator of the Fynn-Weischel Motor is Similar to a Standard Induction Motor Stator

pulls the rotor back into synchronism. This characteristic enables the motor to carry temporary excess overloads in the same way that the squirrel-cage or slip-ring induction motor will carry overloads, thereby making the motor as stable and practical in its operation as present types of induction motors.

The advantages claimed for this motor are as follows: The power-factor correction is at the most usual source of low power-factor. Heavy currents drawn by synchronous motors when started or when thrown out of step are eliminated, and the necessity for special attendance for



The Rotor is Provided With a Commutator and Slip-Rings. The Fan at One End of the Rotor Furnishes Directed Draft Ventilation Around the Stator Iron and Through the Rotor Iron Below Slots

operation and adjustment of large synchronous motors is obviated. The motor eliminates the necessity for synchronous convertors or other corrective means at transmission and distribution centers in so far as they may be required for industrial motor loads. Actual energy wasted upon the customer's premises is reduced by from three to five per cent. The motor makes possible a 30 per cent reduction in cost of future plant extensions after present equipment is fully loaded.

General News Section

The Western Electric Company has been appointed distributor by the Chicago Concrete Post Company for the concrete lighting standards and railway supplies used in railway signalling manufactured by the latter company.

The "Pittsburgher" is the name of a new through night passenger train of the Pennsylvania, between New York City and Pittsburgh, which will be put in service on January 14. The time of train No. 37, the Iron City Express, will at the same time be shortened.

The Dixie Limited of the Nashville, Chattanooga & St. Louis, southbound, was derailed at Kennesaw, Ga., on December 22, and the locomotive was overturned. The engineman was killed and two other trainmen were injured. Injuries to passengers were all reported as not serious.

The Sprague Safety Control & Signal Corporation, New York, has opened a permanent western branch in Room 959, Illinois Merchants Bank building, Chicago. F. D. Sprague, chief engineer, will be in charge with technical assistants to handle both the train control and additional signal work.

The City of Chicago is renewing its efforts to secure immediate action on the part of the roads entering that city in elevating their tracks. Presidents of the roads with terminals in Chicago have been invited by Commissioner of Public Works Sprague to state their positions on the matter in early conferences.

The Gibb Instrument Company of Bay City, Michigan, manufacturers of Electric Welding Equipment, announce the appointment of Glenn A. Wilson as manager for New York and New England territory, with headquarters at 120 Liberty street, New York. Mr. Wilson formerly represented the Mutual Electric and Machine Company.

The Erie Railroad Co. has purchased two new 400 hp. B. & W. boilers and two Westinghouse new model underfeed stokers for installation in its shops at Hornell, N. Y. These stokers will be driven by direct current motors. Baldwin chain drives will transmit power from the motors to the stoker. Positive air pressure under the grates will be furnished by Wing turbo-blowers controlled by Ruggles-Klingman regulators.

The General Electric Company has created a southwestern district to handle its apparatus business in Texas, Oklahoma, Southern New Mexico and southeastern Arizona. The Southwest General Electric Company, as such, will continue to act as distributing jobber in the southwestern district. C. W. Hobson has been appointed southwestern manager in general charge of General Electric business in that territory, and L. T. Blaisdell, district manager.

Train Dispatching by Radio

The Southern Pacific on December 7 directed the operation of trains on its Coos Bay branch by radio, sending orders from the government radio station at Marshfield, Ore., to the government radio station on Puget Sound and from there to Eugene by Western Union telegraph. This expedient was adopted because of a storm which caused all wires to fail.

Burlington Opens New Denver Shops

The opening of the new shops of the Chicago, Burlington & Quincy at North Denver, Colo., recently was marked by a formal dedication which was attended by a large number of Burlington officers, representatives of other roads and business men and local officials of the city. Invitations to the dedication were extended to 560 Denver business men and large numbers responded. Following a luncheon in the new building, Governor Sweet of Colorado, Mayor Stapleton of Denver, vice-president Baldwin of the Burlington, former governor E. M. Hammons and Thomas B. Stearns, representing the contractors who constructed the shops, gave short talks. A trip of inspection through the shops followed. The speakers at the dedication termed the shops the "biggest single improvement brought to Denver in its history." The plant will be used primarily for the repair and rebuilding of locomotives used on the Colorado & Southern and on the Burlington lines in Colorado, Wyoming and western Nebraska.

Baltimore & Ohio to Electrify Staten Island Lines

Plans are being made for the electrification of the Baltimore & Ohio lines on Staten Island, New York. It is expected that the first section to be undertaken will be the line of the Staten Island Rapid Transit Railway from St. George to Tottenville and South Beach. This includes about 16 miles of line carrying suburban passenger traffic and will involve an expenditure of approximately $6,000,000. After this, the electrification of the remaining passenger lines will be completed and the railroad will then give its attention to the freight lines. The character of construction and type of equipment to be used has not yet been decided upon.

A tunnel to Staten Island, connecting with the present subway system on Manhattan Island, may be built, but whether subway trains from Manhattan will be run through the tunnel and then over the lines on Staten Island has not been determined. The Staten Island lines at present bring 32 trains into St. George within two hours every morning and so many additional trains could probably be accommodated in the present subway system of Manhattan. To meet this condition additional subway systems would have to be provided on the lower part of Manhattan Island as well as the tube to Staten Island.

That the electrification of the Staten Island lines cannot be completed by January 1, 1926, as provided for in the Kaufmann Act, is a foregone conclusion. As much of the work as possible will be completed by that date. After that time an extension of time is hoped for.

Another possibility is that the act may be revised so that only a part of the freight lines of the railroad will have to be electrified.

Huge Hydro-Electric Unit for Niagara Falls

The world's largest hydro-electric power unit was placed in commercial operation at Niagara Falls, December 18. The generating unit is a 65,000 kv-a. 107 r.p.m., 12,000 volt, 25 cycle vertical waterwheel driven generator, driven by a 70,000 h.p. hydraulic turbine, with a total weight of over 1,750 tons. It is the first of two such units now being installed by the General Electric Company and the William Cramp & Sons Ship & Engine Building Company of Philadelphia. The station, when completed, will have a rated capacity of 454,000 horsepower. The unit just installed uses 3,500 cubic feet of water per second with an efficiency of at least 93 per cent. Using the same amount of water formerly used by seven 5,000 horsepower units, it delivers energy equivalent to the output of fourteen such units.

Electric Storage Battery Co. Erects New Building

Work is well under way on the new building of the Electric Storage Battery Company at Vandeventer and Chouteau Avenues, St. Louis, Mo.

With the steady growth of business, larger quarters were necessary to enable the St. Louis Branch to handle their work in an efficient manner. The new building now under way, has 32,000 square feet of floor space.

The building itself will be of mill type construction. Sixteen foot steel sash and saw tooth skylight over one hundred feet in length assure ideal daylight working conditions. Reinforced concrete shipping platforms are being installed with the most modern equipment for the handling of materials. Shower baths, locker rooms and lunch rooms are being provided.

The administration offices of the St. Louis Branch will all be housed in this building from which the needs of Exide batterymen in the states of Missouri, Southern Illinois, Arkansas, Louisiana, Oklahoma and Texas, will be cared for.

Personals

C. P. Taylor has been appointed electrical engineer of the Norfolk & Western with headquarters at Roanoke, Va., succeeding C. H. Quinn, resigned.

A. E. Tregenza, for the past eleven years general sales manager of the Economy Fuse & Manufacturing Company, Chicago, has resigned.

Nicholas M. DuChemin has assumed the duties of general superintendent of the West Lynn plant of the General Electric Company following the death of William J. Lloyd on October 28. This follows an announcement recently made by F. P. Cox, manager of that plant. Mr. DuChemin was born in New York City in 1895 and is a graduate of St. Bonaventure's College, Newfoundland, class of 1913, where he won the Rhodes scholarship. He joined the General Electric apprentice school at the River Works in Lynn and also the engineering school. In addition to this he attended the Suffolk Law School in Boston and took a year's course at the Boston University. During the years 1917 to 1919 he was in the United States navy, enlisting as a seaman and finishing with the commission of lieutenant in charge of construction work for aviation uses. Following his naval service he returned to the Lynn plant of the General Electric Company as a boring mill hand. He soon won promotion and his safety work caused his being put in charge of the Bedeaux point system in the West Lynn plant, the position he occupied when he received his recent appointment.

Charles H. Quinn, chief electrical engineer of the Norfolk & Western, has resigned, effective December 15, 1923. Mr. Quinn was born in Sacramento, Cal., in 1874.

C. H. Quinn

His first railroad experience was gained on the Southern Pacific at San Antonio, Tex., where, in 1892, he entered the service as machinist's apprentice. Later, he completed his education at Purdue University, where he was graduated in 1899 as an electrical engineer. While going through school, Mr. Quinn put in two periods of three months each as journeyman machinist on the Mexican International and in customs service of the government. After his graduation, he remained at Purdue University for two years as instructor in mechanical engineer drafting and shop practice. In 1901, he went to the Norfolk & Western as a draftsman. After a year in the service of this road, he was promoted to electrical foreman which position he held for five years. During this time he had the direct supervision of laying out plants, both steam and electric. While in this position, much of Mr. Quinn's work consisted of changing over steam plants into electric plants, including the terminal at Portsmouth, Ohio. In 1906, he was appointed assistant engineer of motive power. The work of investigation looking towards the electrification of the Norfolk & Western was begun in 1910 and electrification was authorized and installed in 1915. In 1914, Mr. Quinn was promoted to chief electrical engineer of the road which position he has held up to the time of his resignation.

William Porter White has been appointed to act as personal assistant to M. O. Troy, new executive assistant manager of the central station department of the General Electric Company, according to a recent announcement. His headquarters will probably be at Schenectady in common with Mr. Troy.

Mr. White was born at Beaufort, S. C., in 1885, receiving his early education in the grammer and high schools. He is a graduate of Clemson College, class of 1906, whence he entered the student test course at the

Pittsfield works of the General Electric Company. In 1908 he started work in the transformer engineering department there, where he received a thorough training in designing. In 1911 he was transferred to the transformer sales department at Schenectady and, in 1912, was placed in charge of exploitation and sale of feeder voltage regulators and generator voltage regulators. He received another promotion in 1913, taking charge of commercial engineering work in the transformer sales department at Pittsfield.

He has taken active interest in A. I. E. E. and N. E. L. A. activities, as well as work in the Electric Power club. He is past chairman of the Pittsfield section of A. I. E. E. and a present member of its executive council.

L. R. Brown has been appointed manager of the transformer division of the new central station department of the General Electric Company, according to a recent announcement. He was one of the company's first transformer specialists and has a wide personal acquaintance in the central station industry.

Mr. Brown is a graduate of the University of Wisconsin, class of 1903. Following early work with the Oshkosh Electric Light & Power Company he entered the General Electric test course at Schenectady. He later took up duties in the switchboard department there working on station layout engineering. With the establishment of the transformer sales department he joined this division in 1906 and spent three years as transformer "missionary" in the Chicago, Texas and New York territories. In 1911 he was made head of the distribution section of transformer sales, including exploitation, quotation, distribution system and service. In 1913 he established the first transformer commercial offices at Pittsfield and continued as head of the transformer department there until the transfer of the other section of the transformer department to Pittsfield.

In connection with the reorganization following this and other changes in the central station department, G. G. Jeter, H. F. McRell and Clinton Jones are to be sales managers in this division. Mr. Jeter will have charge of transformer accessories, advertising and publicity; Mr. Jones will have supervision of power transformers, and Mr. McRell, distribution transformers.

Trade Publications

The Johns-Pratt Company, Hartford, Conn., is distributing a one-page, illustrated folder showing its Noark universal service switch.

Sangamo Electric Company, Springfield, Ill., has just issued a small, illustrated, envelope folder showing the various types of meters which it manufactures to meet the requirements of different circuits.

Central Electric Company, Chicago, Ill., has just issued its new catalogue No. 95. The booklet consists of 16 pages and contains illustrations and descriptions of the various types of lighting fixtures manufactured by the company, under the trade name of Attalite. The separate price list accompanies the catalogue.

Copper Clad Steel Company, New York City, has recently issued a four-page folder entitled, "Technical Data and Tables on Copper Weld Signal Line Wire." Accompanying the wire data is a single sheet giving information on copper weld ground rods. This information is illustrated and specific details are given explaining the exact method of making the connections.

The Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., has issued a 24 page booklet, entitled "A Material of Endless Possibilities," containing information about Micarta and the many uses to which it has been put, and indicating the possibilities for other applications. Some of the products for which Micarta is already used are bushings, cord terminals, discs, fan blades, gears, gaskets, handles, insulators, knobs, pinions, pulleys, radio panels, switchboards, telephone apparatus and washers.

The Westinghouse Electric & Manufacturing Company has issued the first number of a miniature publication entitled, "Electric Heat." This publication which will be published frequently is devoted to industrial electric heating problems. In this issue there are articles concerning the use of electric heat in the manufacture of storage batteries, electric motors and many other subjects. Of especial importance are articles by Professor W. Trinks of the Carnegie Institute of Technology on "Advantages and Limitations of Electric Heat" and "Reduced Labor—A By-Product," by M. R. Armstrong. The method of calculating power requirements of electric ovens is given together with a number of ways in which hard jobs may be made easy by electric heating.

Manual of Instruction for Welding Operators.—This manual contains a complete set of outlines of lessons, exercises and examination for the training of oxy-acetylene welders and electric arc welders. In the outline of lessons a great deal of care has been exercised to provide a logical development of welding instruction, and to give reading references which will enable the instructor and student to secure full information on every topic in the outline. The exercises in each course start with an exercise in setting up the apparatus for welding, and carries the student through the more general operations, then provides special exercises typical of the work done in some of the more important industries which are large users of the welding processes. In the case of each exercise the objective is clearly stated and auxiliary information is supplied covering the important points which might be overlooked by the student in his course of reading. Lessons and exercises are supplemented by lists of general and special examination questions. These questions may be made to serve a threefold purpose. The instructor can use them to determine how much the student has gained from his course of instruction; the employer can use them to determine the ability of the applicant for a welding position, and the welder himself can use them as a check on his own knowledge of the work which he is doing. The manual contains two pages of color charts, one of them illustrating the appearance of metal at varying temperatures and the other showing the proper adjustment of the oxy-acetylene flame. There are also two pages of illustrations showing step by step how to assemble the oxy-acetylene apparatus and get it ready for operation. This little booklet has been prepared for the use of welding instructors, welding foremen, welding supervisors and welding students. It will be sent free to interested parties by The Welding Engineer, 608 S. Dearborn St., Chicago, Ill.

Railway Electrical Engineer

Volume 15 FEBRUARY, 1924 No. 2

Practical Magnetic Analysis

A method for determining the character of iron and steel sections without testing samples to destruction is described elsewhere in this issue. The process is magnetic, and depending upon what characteristic of the metal is to be determined, various properties and factors such as permeability, reluctance, hysteresis and coercive force are employed.

Development of the process has been under way for a number of years but practical applications have been made only recently. Scepticism may be justifiable on the ground that the process is new and is used very little commercially, but it may also be said that it has been approved by prominent engineers not interested in its commercial development. Several examples are given of its application and others will suggest themselves to the electrical engineer. For example a magnetizing coil can be placed around an elevator cable and exploring coils inside of the magnetizing coil connected to a galvanometer or relay. With the cable in perfect condition the exploring coils will be inoperative, but if a strand is broken, the galvanometer will register that fact as the cable is passed through the coil. Surely it is a process which has great possibilities for use by the railroads or for testing materials offered for purchase.

The Railroad Situation

Technical men seldom interest themselves to any great extent in the railroad problem as a whole, but a working knowledge of the situation as it changes from month to month is desirable, and to have such a knowledge might be considered as the duty of everyone employed by a railroad; a duty not only to the railroad, but also to himself.

The railroad situation was presented to the public at the evening session of a transportation meeting held at Philadelphia, Pa., February 5, under the auspices of the American Institute of Electrical Engineers. What was said at the meeting is not reported in the *Railway Electrical Engineer,* but many of the readers, among whom there is a high average of radio fans, listened to the speakers. Nothing of technical interest was discussed, but points were brought out which are of vital interest to everyone. For example, such statements as the following were made: "Transportation is everybody's problem"; "The roads must now make large progress in expansion of facilities if they are not to be swamped by the growing needs of the country"; "Investors' dollars cannot be commandeered; they must be attracted by the railroad's earning power and credit." "Agriculture and railroads are singularly dependent upon each other." "The railroads are in need of reasonable taxation and less governmental regulation."

These according to our best railroad authorities are points of fact and certainly such facts placed in the hands of the public will not be detrimental to the railroads. It is easy to criticise and often difficult to answer criticism. A general knowledge of the situation, however, is a great asset in meeting cant and criticism and any man who boosts his own railroad is boosting his own job.

Traction Requirements Outlined

Probably no more useful meeting dealing with electric traction was ever held than the transportation meeting of the American Institute of Electrical Engineers in Philadelphia, Pa., Tuesday afternoon, February 5. It is reported elsewhere in this issue. None of the information presented smacked of exaggeration or exploitation and during the discussion the railroad representatives described railroad operating conditions and specified certain things the electrical engineers must do if they wish to increase the number of electric traction installations on the railroads.

Much credit is due to L. G. Coleman, assistant general manager, Boston & Maine, J. E. Crawford, assistant general manager, Norfolk & Western and William Elmer, division superintendent, Pennsylvania, for their unbiased and intelligent presentation of the railroad problems.

Good and Bad Equipment

The industrial world today is so constituted that whenever any first-class device makes its appearance on the market, it is followed in a remarkably short time by an inferior imitation which claims to possess all of the qualities of the original device, but at a lower cost. There are no doubt times when the imitation article is the equivalent of the original product, but it is not often. Much more frequently it happens that the second device is not only lower in cost but very much lower in quality, and it behooves the careful purchaser to beware of these imitations. It must ever be kept in mind that any consideration of cost should not be based entirely upon the purchase price of the article as this is only one factor in the actual cost, and very often, the smallest factor to be considered.

The important thing to give attention to is the length of time which the device will give satisfactory service. Too frequently material and equipment of all kinds is purchased on a price basis entirely, with the inevitable

result that the ultimate cost is very much more than it would have been if the higher priced original article had been purchased. There is probably no other line of equipment where this is more true than in the case of electrical supplies of all kinds. The very fact that the list of electrical equipment runs into thousands of items makes it a most fruitful field for the unscrupulous imitator whose sole object is to secure one-time sales on a low first cost basis. Fortunate is the electrical man who is able to specify his whole line of supplies and unhappy indeed is he who is obliged to use the material which has been purchased by someone who does not appreciate the value of endurance in service.

The subject is by no means a new one. It has been a most important issue on many railroads for years between electrical men and purchasing departments. However, there seems to be a growing tendency on the part of the purchasing departments to give more consideration to the recommendations of the electrical engineers than there once was, with the result that better material is being secured and better service is being rendered at a lower cost in spite of the fact that the first cost appears to be high. There is nevertheless plenty of opportunity for furthering the cooperation between the purchasing departments and the electrical men and the latter should be constantly alert to use their influence towards the purchase of reliable and serviceable equipment. In this way the integrity of their departments may be maintained and reliable service furnished even under the most trying conditions of operation.

Still More Train Control

The old adage, "It never rains but it pours," was never better exemplified than in the recent order of the Interstate Commerce Commission requiring train control installations on 45 roads not included in the previous order issued by the same body on this subject. While the roads affected by the previous order were still stewing about their problems in meeting the requirements, the second edict came like a bolt from a clear sky. Not alone are the 45 additional roads affected by the new order, but the original 49 roads which were included in the first order are obliged to install a second division when few of them have completed plans for the installation on the first division. The problem of train control is undoubtedly the paramount issue of the year.

While it might not be entirely apparent at first glance, the real reason behind the second order of the Interstate Commerce Commission is the increasing demand of public opinion for more safety in the operation of passenger trains. Each rail accident serves to make it more apparent that steps must be taken which will reduce, if not completely eliminate, the disastrous head-on and rear-end collisions which continue to occur even on double track and well signaled roads.

There is little doubt but that the era of train control is near at hand. From the electrical man's point of view, it means that he must give much attention to the subject. There are many different types of systems of train control available, quite a number of which are fully capable of meeting the requirements of the Interstate Commerce Commission. The railway electrical engineers must familiarize themselves with the general principles of these as rapidly as possible so they may be in a position to discuss them intelligently when occasion arises. It does not require a great amount of consideration to foresee that such occasions are inevitable.

Having once decided on any particular system on a given road, the electrical engineer of that road should lose no time in acquiring a complete understanding of that system, for the present indications are that he will have much to do with its operation and maintenance. The subject opens up a new field for the electrical men and embraces at least one new angle with which they have heretofore had nothing to do, namely the air brake equipment. It is not alone sufficient to be familiar with the electrical equipment which is required in the operation of train control apparatus on the locomotive, but the electrical man who knows his job will go further and learn much more concerning the whys and wherefores of the air-brake equipment, a thing which has never interested him before. The number of electrical men who are familiar with the operation of the automatic air brake apparatus, which is so vital to railroad operation, is pitifully few. Some know in a general way how the equipment functions, but in order to cope with the situations which are bound to arise when train control becomes an established feature, a far greater knowledge of the subject than that possessed by the majority will prove a very great asset on many an occasion. You may not know now what system of train control your road will adopt, but the automatic air brake equipment is the same on all roads and there can be no possible excuse for electrical men not being familiar with this angle of the big problem of the day.

New Books

Emergency Braking of Electric Cars—By D. D. Ewing. Bulletin No. 13, Engineering Experiment Station, Purdue University, Lafayette, Ind. 164 pages, 6 in. by 9 in.

This bulletin contains the report of a series of emergency shop tests made with four types of city and interurban electric cars. The investigation was a co-operative one, participated in by Purdue University, the Central Electric Railway Association and the Westinghouse Traction Brake Company. The manner in which the tests were conducted, the results obtained and the conclusions reached are given in detail.

Technical Writing. By T. A. Rickard, 2d edition. N. Y., John Wiley & Sons; Lond., Chapman & Hall, 1923. 337 pp., 8 x 5 in., cloth. $2.00.

Contents: General principles. — Naturalness. — Clearness.—Precision.—Superlatives and the superfluous.—It, one, where, while, since.—The subjunctive, shall and will, and the possessive.—Relative pronouns.—Prepositions and preposition-verbs.—Hyphens and compound words.—Slovenliness.—Jargon.—The wrong word.—Construction.—Punctuation.—Composition.—Style.

Mr. Rickard's book will be useful to every engineer who desires to write clearly, correctly and pleasantly. He calls attention to many common faults in technical writing, illustrates them by many examples and shows how they might have been avoided. The advice given is practical and is based on lengthy editorial experience. The new edition has been corrected, and partly rewritten, and enlarged by two new chapters.

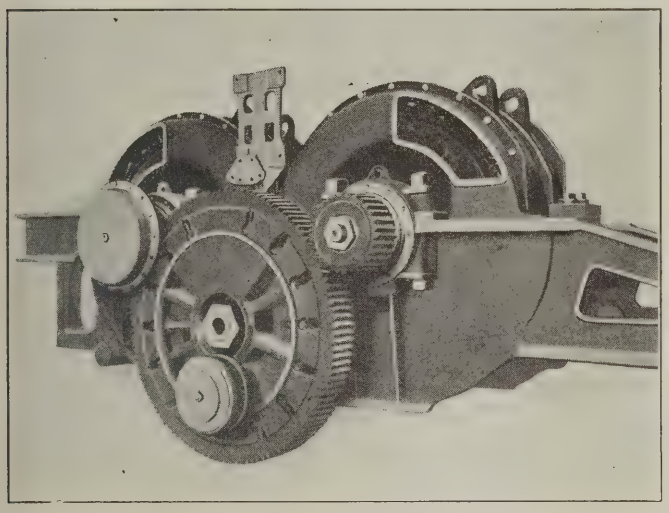
Pennsylvania Builds Three Electric Locomotives

Machines All of One Design But One Will Be Used for Freight and Two for Passenger Service

By T. C. Wurts

General Engineer, Westinghouse Electric & Manufacturing Company

AT the Altoona shops of the Pennsylvania there are now being built three 200-ton electric locomotives, all of the same type. One of these is to be used for freight under the single phase alternating current trolley, while the other two are to be given extensive tests to determine their adaptability for passenger service, after which it is proposed to use them as direct current locomotives on the New York tunnel and terminal division of the railroad.



Two of the Single Phase Motors Mounted in Cradle, Showing the Springs in the Gear Center

With the prospect of extensive main line electrification in the near future, and with the probability of the electrification of the Altoona grade before many years, the Pennsylvania Railroad built a split-phase locomotive of 4,000 hp. continuous rating, known as the "FF-1" locomotive, and placed it in service in the spring of 1917. The war and Government control of the railways, combined with other causes, delayed somewhat the test of this locomotive, which is now in regular freight service between Philadelphia and Paoli.

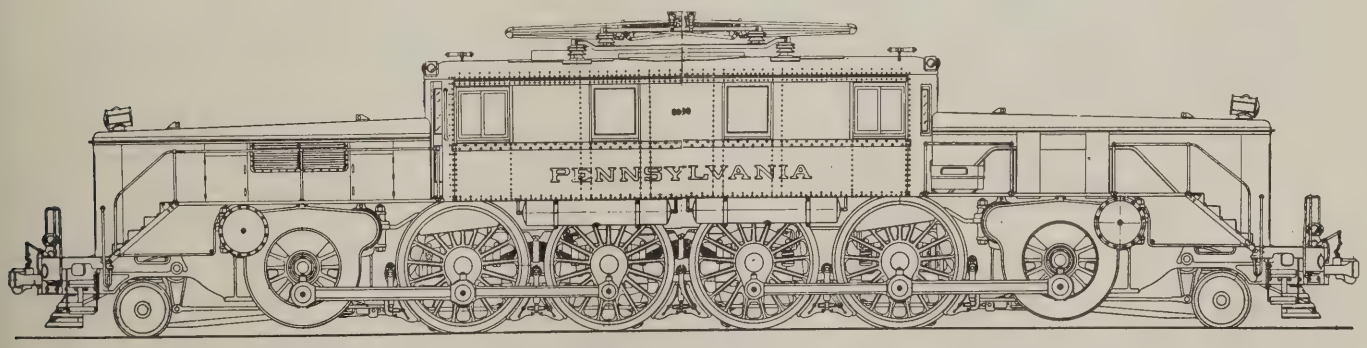
Each of the three new locomotives will weigh approximately 400,000 pounds, and will be equipped with four single phase commutator type motors. These motors have a continuous rating on single phase power of 760 hp., giving a total locomotive rating of 3,040 hp.

The locomotives have a 2-8-2 wheel arrangement with the so-called "steeple" type cab construction. The motors are arranged two per jack shaft, and are mounted outside of, and at either end of, the driving wheelbase. Each jack shaft serves two pairs of drivers. The connection between the motors and the jack shaft is by means of pinions and flexible gears.

The single phase freight locomotive will have a gear ratio of 30:118 and a maximum speed of 35 miles an hour. The two locomotives that are being arranged for direct current passenger service over the New York tunnel and terminal division will have a gear ratio of 50:98, permitting a maximum speed of 70 miles an hour.

Although two of these locomotives are being laid out for d. c. operation, while the third is to operate under an a. c. trolley, the motors and all other parts possible are being made identical. The space required for the transformer on the a. c. locomotive is devoted to accelerating resistance on the d. c. locomotives. The pantagraph on the a. c. locomotive gives place to the third rail shoe on the d. c. locomotives, etc.

Side rods will be utilized for the transmission of power from the jack shaft to drivers. Flexibility between the motor armature and the running gear will be provided by springs set in the gear center, and flexible pinions in one of each pair of motors geared to their common jack shaft. These springs in the gear center and in the pinion have been especially devised by the Westinghouse Electric & Manufacturing Company. They are of the leaf type, and are inserted into their pockets without any initial tension, and are so designed that they will be active throughout the

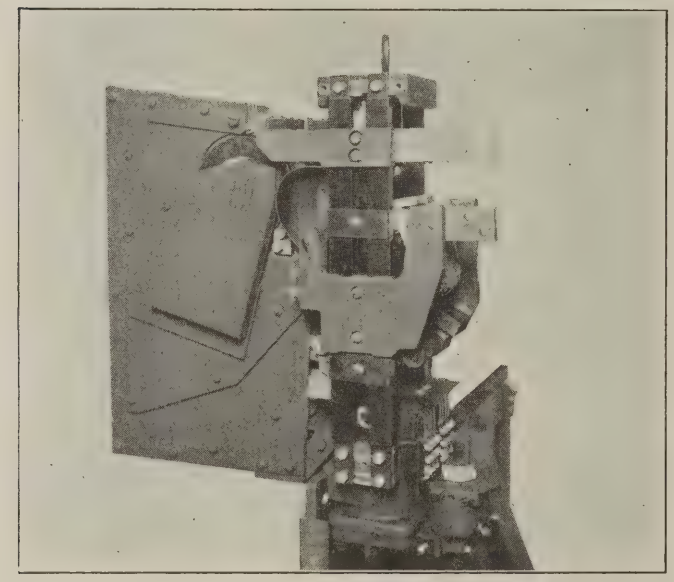


Side Elevation of One of the Locomotives. The Principal Dimensions are: Dia. of Drives 80 in.; Driving Wheelbase 22 ft. 3 in.; Dia. of Guiding Wheels 36 in.; Total Wheel-Base 54 ft. 11 in.; Length Inside Knuckles 68 ft. 2½ in.

operating range of the locomotives. Throughout the design of these locomotives, the underlying principle adhered to has been that of extreme simplicity.

A. C. Freight Locomotive

The outstanding feature of the freight locomotive is the traction motor, which has the largest capacity possible under the limitations prescribed by the Pennsylvania Railroad. It should be noted in this connection that this motor has the greatest capacity of any single phase commutator type traction motor that has ever been built in this country. Some idea of its size can be gained from the following figures: The outside diameter of the frame is 76 inches, while the motor is 43¾ inches long. The main frame of the locomotive is so designed and machined that it forms a cradle into which the motor is inserted, thus making the latter an integral part of the locomotive main frame. The motor bearings are carried on the side frames of the locomotive, and are entirely separate from the main frame of the motor itself, but are integral with the motor cradle. In order to maintain the high rating previously mentioned, forced ventilation has been necessary, air being



There Are 21 of These 1500-Ampere Electro-Pneumatic Unit Switches on Each D. C. Locomotive

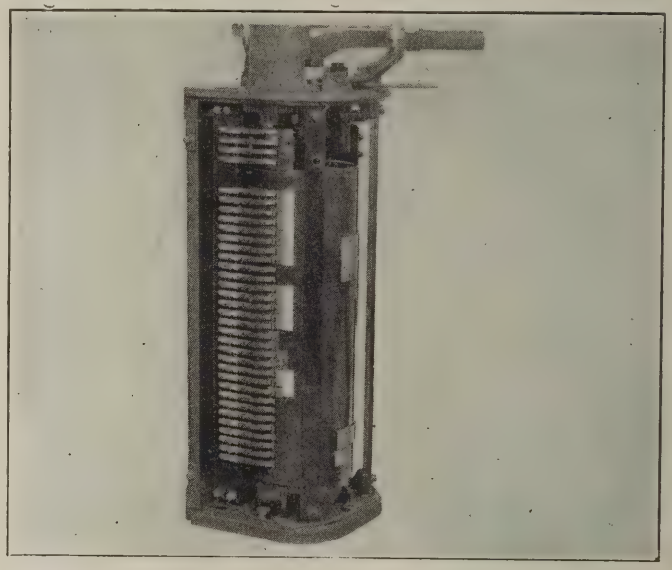
drawn through the motors instead of blowing it through as has been the usual practice with forced ventilation.

Another interesting and novel feature of this locomotive is the use of an oil-insulated, force-cooled transformer. The tank of this transformer is built into the locomotive, but it is entirely separate from the cab structure. Its base rests on pads on the locomotive main frame, while the top is formed by a portion of the cab roof, but at no point is it rigidly connected to the cab structure. The sides of this tank are formed from a single sheet of steel, with a vertical seam joined by a double row of rivets. The bottom of the tank, which is an integral cup shaped piece, is set into the side sheets and riveted into place.

The transformer oil will be cooled by being pumped through a forced ventilated radiator. A single motor is provided to drive both the oil pump and the blower which provides the ventilating air.

The locomotive roof is constructed so that the removal of the transformer core from the locomotive can be accomplished by simply removing that portion of the roof directly over the transformer.

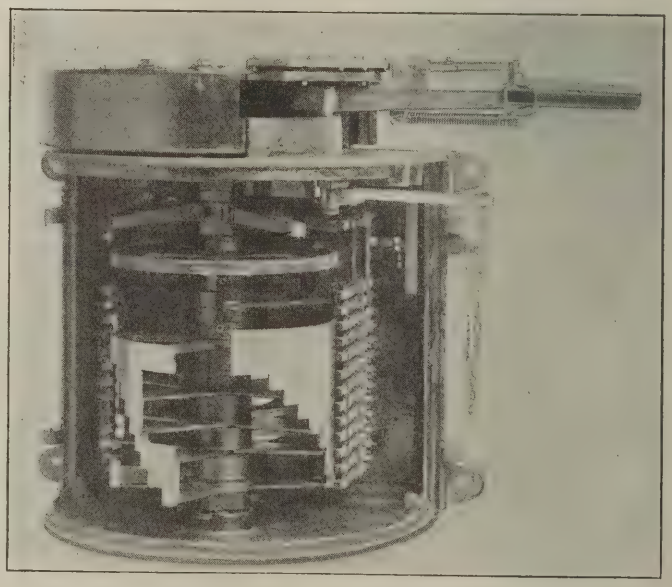
Two motor-driven blower sets are provided, one for each pair of traction motors. The motors driving these sets and the motor driving the oil pump and blower mentioned above are identical with the single exception of the



Master Controller for the Alternating Current Locomotive

shaft extension. This feature lends itself to simplicity and ease of maintenance.

The control of the traction motors again emphasize simplicity. The apparatus provided consists only of a master controller, a reverser, the necessary unit switches for a notch-by-notch voltage increase to the normal voltage of the traction motors, preventive coils, and the minimum number of relays consistent with safety. In addition to



Master Controller for the Direct Current Locomotives

this apparatus there is a small motor-generator set for charging the storage battery which furnishes the energy for the control apparatus and lights. The brake system is of the standard locomotive type. The brake lever system is designed for clasp brakes, giving 100 per cent braking power at the driving wheel.

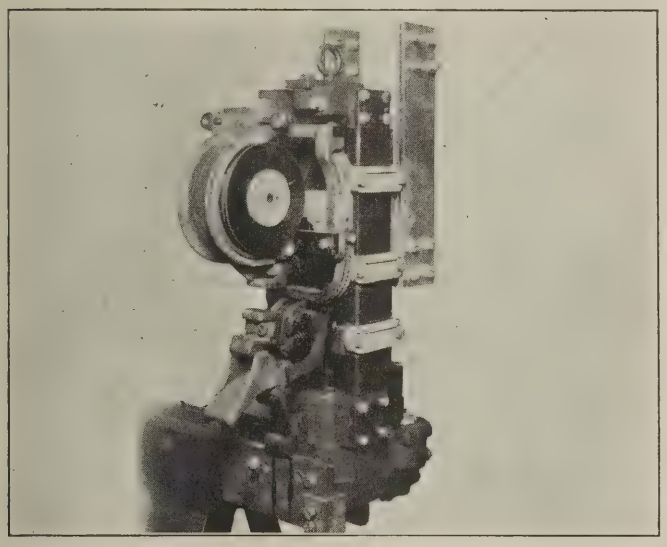
LOCOMOTIVE CAPACITY

	Continuous	Hourly
Tractive effort (lb.)	50,000	62,000
Speed (M. P. H.)	23	19.75
Maximum T. E. (lb. at 33 1-3% adhesion)		100,000
Maximum speed (M. P. H.)		35

The locomotive capacity as given in the table means that the locomotive is capable of hauling 2,370 adjusted tons up the slope west of Altoona, Pa., at an approximate speed of 24 miles an hour.

D. C. Locomotives

As indicated earlier in the article, the passenger locomotives are of the same fundamental design as the freight



One of the Twenty-three 3000-Ampere Electro-Pneumatic Switches Used on Each D. C. Locomotive

locomotive just described, and are intended for operation on the New York tunnel and terminal division. The traction motors are identical to those used on the freight locomotive, and with the gearing provided the locomotive is capable of handling the largest Pullman train entering or leaving the New York terminal.

The blower sets are also a duplicate of those on the a. c. locomotive. A number of parts on the electrical equipment required for d. c. operation which cannot be made duplicate of the parts on the a. c. locomotive have been made duplicate of the parts on the present tunnel and terminal locomotives. Among these parts may be mentioned the third rail shoes, resistance grids, etc.

Mention has already been made of the fact that the motors for these locomotives are in capacity the largest single phase traction motors in this country. The d. c. locomotives have the additional distinction of being equipped with the largest unit switches in existence. These switches are of the standard Westinghouse electro-pneumatic type, and have a continuous capacity of 3,000 amperes. The arc rupturing capacity of these switches is many times this amount on a 750-volt circuit. A total of 23 switches is required on each locomotive to handle the motor circuits.

These locomotives will be completed and placed in service early this year, at which time it is proposed to make extensive tests to determine the practicability of this type of locomotive both for high speed passenger and for freight service.

The Crane Type Truck in the Roundhouse

At a recent discussion among electrical men, the question came up concerning the more extended use of the crane type electric truck. That such a truck is capable of doing much work about a roundhouse that is frequently done in a much more expensive manner may be seen from the illustration. The picture shows a crane placing an air pump on a locomotive. The old pump has been removed and lies upon the tractor platform. With this type of truck, it is practical to bring a new pump from the storeroom, take the old pump off the locomotive, replace it with the new one and carry the old pump back to the storeroom again in a surprisingly short time. Before the advent of the crane type truck, this work was done much more laboriously and at much greater expense.

Where it was formerly necessary to place a locomotive jack weighing 2,000 lb. in the locomotive pit, a common method was to call out the wrecking crew and train to do the job. By driving the crane type truck alongside the pit, however, the boom is used to place or remove the jack. An estimate as determined by officers of one of the roads in two of their roundhouses showed the saving of this

A Crane Type Truck Placing a New Pump

equipment averaging around 1,000 man-hours per month. This type of truck is now used in many of the larger roundhouses of the country and has proved one of the most valuable developments in the railroad field during the last year. The truck shown in the illustration is one manufactured by the Elwell-Parker Electric Company of Cleveland, Ohio.

An electrical exhibition under the auspices of the Victoria Electrical Federation will be held in Melbourne during September, 1924. It is planned to cover every phase of the electrical industry, showing working models of the various types of apparatus from toys to machinery, transport, lighting and other industrial equipment. Both wireless telegraphy and telephony will have prominent places in the exhibition.

Repair of Electrical Indicating Instruments

Causes Which May Make Them Indicate Incorrectly and Remedies Which May Be Applied

By Victor H. Todd
Westinghouse Electric & Mfg. Co.

TWO conditions exist when an indicating instrument is not in order. The instrument may not indicate at all, that is, it not only does not indicate properly, but the pointer does not move appreciably and there is no indication whatever, or the instrument may indicate but not indicate properly.

When an electric measuring instrument fails to indicate, the trouble may be caused by one of four defects: (1) lack of current or voltage, (2) open circuit in the instrument, (3) short circuit of the measuring element and (4) mechanical difficulties. The first three are purely electrical defects and can be located by the proper use of additional instruments, while the fourth can be located usually by a close inspection.

For the mechanical troubles, a kit should be used. This contains necessary tools such as large and small pliers, wrenches, screw-drivers, soldering copper, eye-loop, magnet cleaner, tweezers, soldering flux, etc. The soldering flux is an important item as one of the first rules of instrument repairing is that fine wires or springs must never be soldered with any paste or flux containing the least acid. There are several acid-free compositions on the market which may be used, but an unexcelled paste is made by dissolving powdered rosin in alcohol and adding a little glycerin to prevent drying or caking. This must be used with thin wire-solder and a well-tinned soldering copper to produce perfect electrical connections. No acid or salammoniac and zinc chloride should be used.

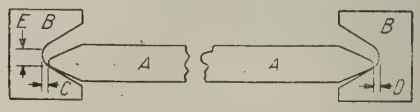
Let us assume that a direct current voltmeter suddenly ceases to indicate. The first point is to see if it is caused by line trouble. Connect a portable standard voltmeter across the terminals of the non-operating voltmeter. Lack of indication denotes line trouble and the voltage should be tested nearer and near the bus or generator until the cause can be located. Loose connections or blown fuses often cause a lack of indication. If there is an external resistor in series with the voltmeter, connect the portable instrument across the line sides of the voltmeter and resistor to ascertain that the line voltage is on; then connect the voltmeter across the external resistor. Indication on both instruments shows an open circuit in the resistor. Lack of indication shows open circuit in the voltmeter and indication of portable instrument alone shows short circuit or mechanical troubles in the voltmeter.

If a portable standard voltmeter is not available, then low wattage lamps (5 or 10 watts) may be used to advantage, except that in some cases the lamps may not light because of high resistance in the voltmeter.

If the voltmeter shows open or short, this may further be confirmed by disconnecting one terminal and connecting the standard in series where lack of indication shows open circuit in either voltmeter or resistor and indication shows either "short" or mechanical troubles in the voltmeter.

"Opens" in the potential circuits of wattmeters, watthour meters, frequency meters, power factor meters, reactive factor meters, and synchronoscopes can be detected by these methods, provided the other circuits of the instruments are functioning correctly. "Shorts" may be determined in the above instruments except those where the total impedance of the potential circuit is in the measuring element, as in the watthour meter. In this case, however, a mild short circuit does not cause non-registration but causes increased registration, while a large short circuit, eventually, causes a burn-out and open-circuit.

Millivoltmeters are tested exactly like voltmeters, except that a portable millivoltmeter should be used in the test. Self-contained ammeters should be tested with a similar range portable instrument, by connecting in parallel, to indicate the presence of current. If the ammeter is open in the main winding, this results in the completion of the circuit and main line current on the portable. Half



Enlarged View of Shaft and Bearing Jewels

line current on the portable indicates either electrical or mechanical trouble in the measuring element.

Let us assume that our original voltmeter has been proven intact electrically but still does not indicate. First, wipe all dust or dirt off the cover and then remove it carefully. Give the pointer a gentle push with a matchstick or toothpick to see if it is stuck (meter elements are usually alive and should be touched with caution). Possibly, it will stay wherever it is pushed and will not return freely to zero. Now disconnect the voltmeter and remove from the board.

One of the most important mechanical points in an electrical instrument is the correct adjustment of "end play." This is illustrated in the sketch where an enlarged and exaggerated view is shown of the shaft *A* with glass-hard, pointed ends and sapphire jewels *B* and *B*. The total distance *C* plus *D* that the shaft can move from end to end is called the "end-play" and the distance *E*, that the pivot can move from one side of the jewels to the other is called the "side-play." End-play and side-play are usually only a few thousandths of an inch and upon the correctness of this detail depends much of the success of the instrument. A most important rule of instrument repairing is, never screw the jewel-screws in until they clamp or pinch the moving element; even once may ruin the pivots.

Correctly designed jewels and pivots, usually, require adjustment of only "side-play" which is done as follows: Lay the instrument on its back and grasping the pointer

gently but firmly with either tweezers or thumb and finger, wiggle it gently back and forth, meanwhile tightening the jewel screw with a screw-driver a fraction of a turn at a time until it wiggles only a few thousandths of an inch (about the width of a paper) and then holding the driver firmly, but not pressing down, tighten the jewel lock nut with a suitable wrench.

It may be superfluous to caution the repairman to ascertain that the pivots are actually in the polished recess in the jewel in making this adjustment and not in a crack between jewel and mount, but many pivots are ruined from this oversight.

The deflection of the induction type instrument varies slightly with frequency changes. This is not objectionable when the instruments are used on an ordinary power system. The small variations of frequency have no influence upon their reading. The latest designed instruments are of the dynamometer type, they read practically the same up to 133 cycles.

The best induction type instruments are the least affected by stray fields and static charges. The well designed iron case of dynometer type meters will shield effectively the stray field encountered in general switchboard practice. The protective influence of the shield falls off as its magnetic density increases and disappears entirely at saturation.

With the induction type instrument, the effect is only noticeable when the stray field is exactly in synchronism with the current in the instrument. In such cases the distance between the instrument and the current-carrying bus should be current inches.

Instruments are also susceptible to external electrostatic effects. These effects usually manifest themselves by an attraction of the pointer toward the glass or case. Under certain conditions, by clearing and rubbing the glass in the cover with a soft rag, the pointer of such an instrument may be moved a considerable distance up scale and remain there for some time.

Direct current instruments using permanent magnets, under normal conditions, have small errors due to external field, but may be permanently affected by such fields under short circuit conditions. The minimum distance between an instrument and a current carrying wire or bus bar should be current inches in order to protect the instrument.

Temperature errors in instruments are due to changes in physical dimensions and changes in electrical constants. It will be remembered that there are two active forces in an instrument; the deflecting and the restraining forces. The deflecting force is the product of the actuating current, and the strength of the reacting element. If the temperature of an instrument increases, it may increase the resistance of its windings; this in turn lessens the current and results in a lower deflection. This is further aggravated by the weakening of the magnetic system due to heating. On the other hand, increased heat tends to weaken the restraining control spring, which tends to produce a higher reading. The correct balancing of these two opposite effects is one of the great problems of design and has been so nearly perfected that the actual error in the best instruments is well within the limits of commercial accuracy.

Mechanical changes are also possible due to heating; for instance, heating may distort a coil, or expand a shaft and mash the pivot ends. The first is overcome by a thorough seasoning of all parts, and the second by correctly designing the shaft so that it has the same coefficient of linear expansion as it supports.

Heating errors are produced from two sources: ambient temperature and self-heating. Over the first, the manufacturer has no control, other than to recommend that the instruments should not be used in places subjected to excessive temperatures, if at all avoidable. The second point is taken care of by means of external shunts and resistors, thus liberating the heat where it will cause no errors, instead of in the instrument cases.

An amount of energy insufficient to cause heating alone will operate the moving elements of any fairly good instrument. It is, generally, the excess energy consumed in series resistors and shunts which causes the excess temperature. The errors due to mechanical causes are probably of greater importance than purely electrical errors, as the causes leading to them, reduce also the life of the instrument and increase the errors with use and time.

Other things being equal, the frictional error of an instrument is proportional to the ratio of torque to weight of the moving element.

The weight of the movement, though very small gives a high pressure per unit of surface as the area of the pivot which has to carry the weight is extremely small. A lighter movement would decrease the pressure per unit of surface, reduce the wear of the pivots and jewels due to service and vibrations. A lighter movement would have in service better sliding surfaces giving less friction and therefore showing better mechanical quality for same ratio of torque to weight of the moving element.

Success in instrument work comes only with absolute cleanliness, as the greatest enemy of an instrument is iron filings and dirt; sooner or later they find their way into the air gap and stop the moving element. To inspect the air gap of a direct current instrument, push a piece of white paper between base and element and then holding the instrument so that the light shines on the paper, look through the air gap. A magnifying glass may be used to advantage, and the least filing or hair or fuzz or dirt should be carefully removed. Iron filings can best be removed by using an iron wire or unbent paper clip and dirt and fuzz removed by using the tweezers or an ordinary chicken-wing feather. Other defects such as loose wire or parts out of alignment are easily discernable by a simple inspection and are generally repairable.

A good instrument should always have the moving element in good mechanical balance; i. e., the pointer should indicate zero no matter in what position the instrument is turned. To secure this, the best instruments have threaded weights, although the principle of balancing is the same in all cases.

The first step is to lay the instrument flat on its back and set the pointer on zero. Then hold the instrument so that the pointer is horizontal and adjust the weight on opposite end of pointer so that it again indicates zero; then turning the instrument so the pointer is vertical, adjust either weight until it again indicates zero. Re-check and adjust the other positions if necessary. The instrument should now be in perfect mechanical balance.

After final inspection, the instrument may be retested and replaced on the switchboard.

After the instrument is repaired, it may be found that it is in serious error due to a variation in spring strength

or magnets. Or it may be desired to change the capacity of the instrument by changing the spring strength. In either case, it is necessary to measure the "torque" or deflecting force of the instrument, usually expressed in millimeter grams. Turn the instrument so that the full scale mark is in a horizontal line with the pivot and then hang a small weight on the pointer, until it deflects the pointer to full scale. Measure the distance from the center of the jewel to the center of the rider in millimeters using a pair of dividers if necessary and multiplying by the weight of the rider in grams. Their product is the torque of the instrument in millimeter grams. In the absence of metric standards, the torque may be calculated in inch-ounces using a copper wire table to obtain the weight of the wire used and reduce to millimeter grams by multiplying inch-ounces by the constant, 718.8.

Assume for example that a piece of No. 24 B. & S. gage copper wire one inch long balances at a distance of 2.25 inches out. From a wire table we learn that No. 24 copper has a weight of .001223 lbs. or .019568 oz. per foot; or .00163 oz. per inch multiplying by 2.25 inches gives .003667 inch-ounce torque. Multiplying by 718.8 gives 2.635 millimeter grams torque.

If the scale deflection is 90 degrees, and two springs are used, then the torque of one spring will be 1.317, for 90 degrees or 5.268 mmg. for 360 degrees, and these are the terms in which the spring should be ordered from the manufacturer.

If it is desired to increase the instrument capacity 100 per cent then springs one-half as strong or 2.635 mmg. should be ordered or if it is desired to decrease the capaterms in which the spring should be ordered.

This discussion of course refers only to instruments in which torque is proportional to the current or voltage applied. If a dynamometer type meter is used, the torque increase as the square of the current or voltage and in changing the capacity, the torque at the desired current or voltage calculated.

For instance, if we have a 5 ampere induction type instrument and wish to change the full scale capacity to 6 amperes due to an increase in load, assume that the full scale torque (300 degrees) is 12 mmg., then the torque at 5 amperes would be

$$(5)^2 : (6)^2 = 12 : x$$

Solving this would give 17.3 mmg. But this is for 300 degrees. Consequently the torque for one revolution, or 360 degrees would be

$$300 : 360 = 17.3 : x$$

Solving this, would give 20.7 mmg. which is the strength of spring to be ordered from the factory.

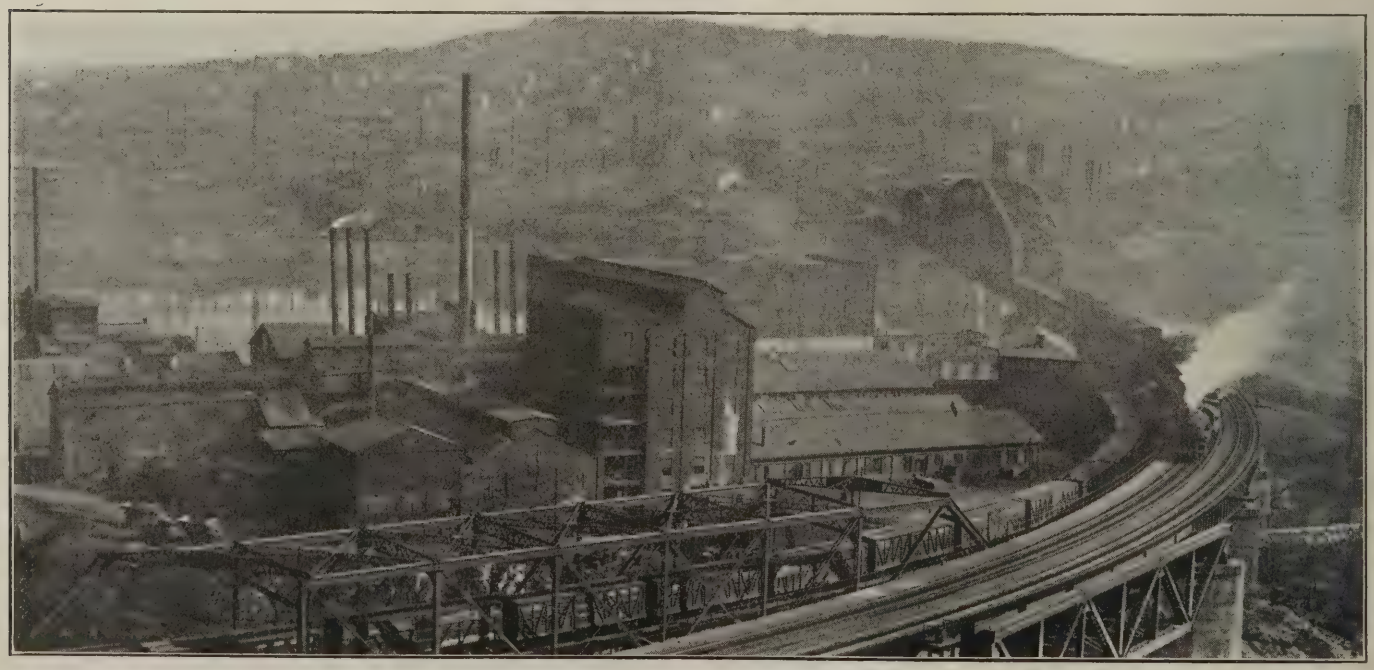
Care must be taken in changing capacities that the winding is not overloaded. If great changes are to be made, the main coil should be rewound. When lowering a capacity, care must be taken not to put a very weak spring in the instrument as the friction may cause very unsatisfactory results.

When the Instrument Does Not Indicate Properly

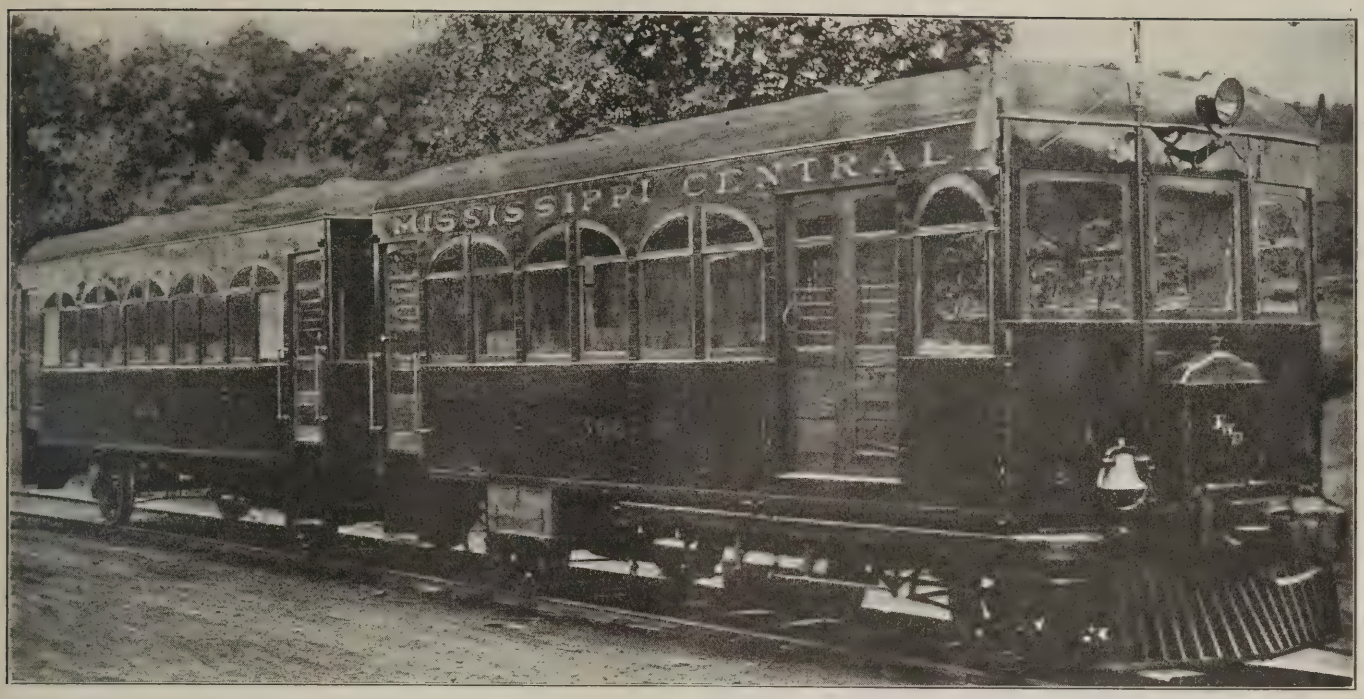
In actual operating practice there are two kinds of errors in any instrument: First, errors of observation due to parallax, width of divisions, etc., which are a percentage of the full scale and independent load; second, errors caused by calibration or effects which vary the constants of the instruments, which are percentages of the actual readings. For simplicity, however, the accuracy at all points of the scale of electrical instruments is stated merely as a percentage of full scale capacity, and therefore the percentage of reading error increases as the load is decreased.

Electrical measuring instruments are delicate mechanisms which require care in handling and correct installation to obtain accurate and reliable results.

It is important, however, to distinguish between the qualities which produce the highest accuracy necessary in laboratory instruments and the quality of ruggedness which is of greater importance in switchboard instruments. For this service what is desired is not so much an instrument which is accurate within a fraction of a per cent when installed, as one which will retain a fair degree of accuracy.



Ewing Galloway **The Baltimore & Ohio In Pittsburgh, Pa.**



Motor-Driven Passenger-Baggage Car and Trailer Built by the Four-Wheel Drive Auto Company

Two-Unit Motor Train for Mississippi Central

Gasoline-Driven Coaches Use Electric Lighting Circuits Patterned After Standard Automobile Practice

THE two-car, motor-driven train illustrated was recently built by the Four Wheel Drive Auto Company, Clintonville, Wis., for service on the Mississippi Central. It will operate from Hattiesburg to Beaumont, Miss., a distance of 27 miles with a ruling grade of 1 per cent and a maximum curvature of six degrees. The motor unit provides space for baggage and seats for 12 passengers. It weighs, complete, 11,000 lb. and has a wheelbase length of 185 in. The trailer chassis seats 34 passengers, weighs complete 6,300 lb. and also has a wheelbase length of 185 in. The lengths of the motor unit and trailer, center to center of the couplers, respectively, are 25 ft. 5½ in. and 27 ft. 5 in.

The motor chassis is provided with a six-cylinder 62 hp. motor having a bore of 5.1. and a stroke of 5.5 in. with a piston displacement of 672 in. While the S. A. E. rating of this motor is 62 hp. it develops 94 hp. under brake test. Force feed lubrication is provided. The cooling system capacity is 15 gal., the water being circulated by the centrifugal pump and cooled in a tubular radiator supported by a 3-point suspension.

Ignition is provided by an Eisemann high tension magneto with impulse starter. The carburetor is of the Stromberg plain tube type. The gasoline system has a capacity of 30 gal. with the tank mounted at the side of the chassis. The gasoline is fed by air pressure, applied through a reducer valve from the air brake system.

The clutch is of the Hele Shaw multiple disc type with a clutch brake. The jaw clutch transmission operates with the gears always in mesh, providing four speeds forward and four speeds in reverse. The reverse gear mechanism is mounted in the sub-transmission. This reverse mechanism contains a differential and permits the power to be transmitted to the car in either forward or backward direction. The mechanism is controlled by a hand lever near the driver similar to the reverse lever of a locomotive and is mounted on ball bearings throughout. It is housed in an oil-tight, dust-tight case and runs in an oil bath.

Power is transmitted from the reverse gear differential to the axles through propeller shafts, each containing universal joints. These have hardened steel bushings and pins and are thoroughly housed in dust-proof, oil-tight casings.

Both front and rear axles are rigid like the rear axles on a truck and are of the full floating type. Each axle contains a differential through which the power is transmitted to the driving wheels. These axle differentials are also completely enclosed in oil-tight, dust-proof housings and run in an oil bath. The weight of the car is taken on these housings and not on the driving axle. Each trailer axle is made of one piece of cold drawn tubing, of 4 in. outside diameter and ¾-in. walls. This tube is turned at the ends to accommodate the spring seats and the roller bearings on which the wheels are mounted.

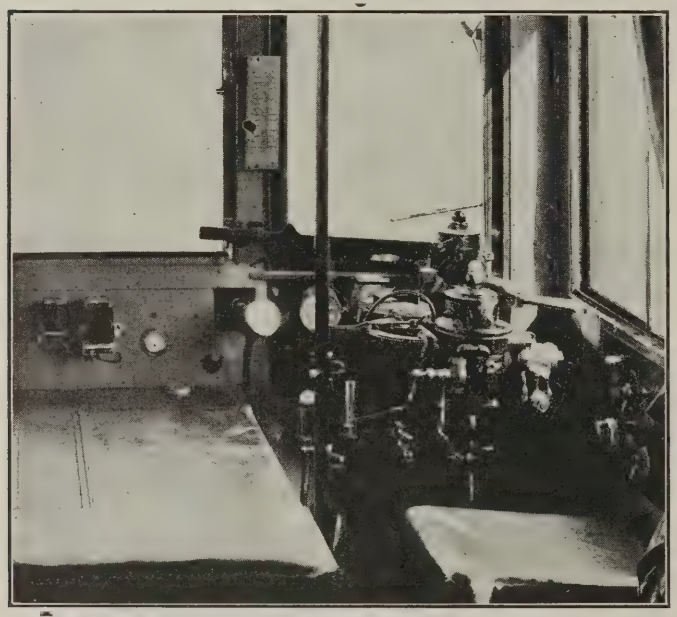
Springs for both the power unit and trailer are 54 in. long, 2½ in. wide and are made of chrome silicon manganese steel, heat treated. These springs are connected to the chassis frame with double-swing shackles which allow the chassis to swing slightly sidewise, thus cushioning the side impacts against the rail and improving the riding qualities of the car. The action of these shackles is very similar to that of the swinging bolster used in railroad cars. The axles are held in place by radius rods, by the

adjustment of which the wheels can be brought into accurate alignment.

The wheels for both the power unit and trailer are of the cast-steel, hollow-spoke type. Tires are of rolled steel and have the standard M. C. B. contour. They are 35 in. in diameter and are mounted the same as demountable solid rubber tires. Ball bearings are used throughout the clutch, transmission, reverse gear and axles.

Cast-iron brake shoes are used on all four wheels, there being one brake shoe for each wheel. A Westinghouse air brake system is provided with an air compressor installed at the rear of the transmission. This compressor has a capacity of 10 cu. ft. per min. and is controlled by an automatic governor. An air strainer at the intake prevents dust and dirt reaching the cylinder. This brake system is provided with all necessary safety valves, emergency valves, operator's valves, application valves, etc. It is a two-pipe system similar to that used on street cars, with a direct air system for service applications and an indirect system for emergency.

One sand box, 7 in. by 10 in., is placed at the rear of



The Convenient Location of Operating Valves and Handles Is Apparent

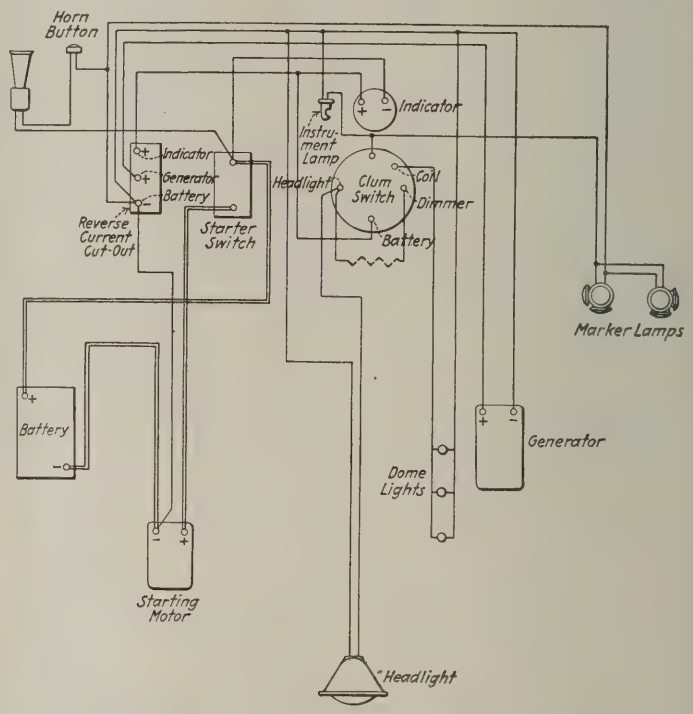
each rear wheel and at the front of each front wheel. The flow of the sand from these boxes is governed by an air valve at the driver's seat with air supplied from the air brake system.

Standard M. C. B. couplers are used, the front coupler having a reinforced wooden filler block and being bolted rigidly to the front of the chassis frame. The rear coupler is of the spring type. The front guard is made of white oak, reinforced and braced in a substantial manner.

Electrical Equipment

A two-unit starting and lighting system is furnished, consisting of a starting motor which operates on the fly wheel of the engine through a Bendix drive. A 270-watt generator and 225-amp.-hr. storage battery are used, the system operating on 12 volts. The wiring is of the single wire type with return through the frame of the chassis. All wires are heavily insulated and carried in steel conduits. Connections are provided for the head light, sufficient body lights, the driver's instrument light and rear marker lights. With this lighting system is furnished one head light, one instrument lamp, a lighting switch, an ammeter and a reverse current cut-out. There are also two oil marker lamps and four marker lamp brackets.

With the chassis is provided in the exhaust line a valve by which the exhaust gases can be shunted through heat-



Wiring Diagram for Lighting and Starting Equipment

ing pipes in the car body. A series of wrought iron pipes is provided beneath the seats at the left hand side of the body and connected with the heater valve. A hot water heating system can be furnished if desired.

The maximum drawbar pull is 3,780 lb., obtainable with

Interior View Showing Walk-Over Seats and Luggage Racks

a gear ratio of 29.40 to 1 in low. The maximum speed with this gear ratio is 5.3 miles an hour and the drawbar pull of 3,780 lb. is obtainable at two-thirds of the maximum speed or about 3.5 miles an hour. With a gear ratio of 15.6 to 1 in low, a drawbar pull of 2,000 lb. is obtainable at about 6.6 miles an hour.

The inside of the cars are oak grained with the head lining painted white. The sashes are mahogany grained. The outside of the cars are painted in Pullman body color, with black roofs, Pullman truck color platforms and black enameled iron work. They are lettered and striped with imitation gold paint.

Additional Train Control Installation Required

Forty-five Roads Not Included in Original Order Must Equip One Division by February, 1926

THE Interstate Commerce Commission on January 14 issued an extension of its train-control order of June 13, 1922, requiring 45 additional railroads to instal automatic train control devices on a full passenger locomotive division by February 1, 1926, and also requiring 47 of the 49 roads named in its original order to make an installation on an additional division. The two roads excepted are the Richmond, Fredericksburg & Potomac and the West Jersey & Seashore, which have but one division.

Whereas the original order named roads having operating revenues of $25,000,000 annually, the new order and the old order together now take in 94 of the 194 Class I roads. (Those having annual revenues of over $1,000,000.)

After referring to the previous order the new order says:

"And it further appearing, That safety of operation and of persons and property require the extension of the protection afforded by such devices as rapidly as possible * * *:

"It is ordered, That the following carriers by railroad subject to the interstate commerce act be, and each of them is hereby, required to instal on or before the 1st day of February, A. D., 1926, automatic train-stop or train-control devices applicable to or operated in connection with all road engines running on or over at least one full passenger-locomotive division included in the part of the main line of each such carrier by railroad between the points hereinafter designated; and the installations herein required shall be made in addition to the installations, if any, heretofore ordered in this proceeding to be made between the same points or upon any other portion of the line or lines of any of the carriers named:

*Atchison, Topeka & Santa Fe, between Chicago, Ill., and Newton, Kan.
*Atlantic Coast Line, between Richmond, Va., and Charleston, S. C.
*Baltimore & Ohio, between Baltimore, Md., and Pittsburgh, Pa.
Bangor & Aroostook, between Northern Maine Jct., Me., and Van Buren, Me.
Bessemer & Lake Erie, between Erie, Pa., and East Pittsburgh, Pa.
*Boston & Albany, between Boston, Mass., and Albany, N. Y.
*Boston & Maine, between Boston, Mass., and Portland, Me.
*Buffalo, Rochester & Pittsburgh, between Buffalo, N. Y., and Butler, Pa.
Carolina, Clinchfield & Ohio, between Elkhorn City, Ky., and Irwin, Tenn.
Central New England, between Hartford, Conn., and Millerton, N. Y.
Central of Georgia, between Atlanta, Ga., and Savannah, Ga.
*Central of New Jersey, between Jersey City, N. J., and Scranton, Pa.
Charleston & Western Carolina, between Augusta, Ga., and Port Royal, S. C.
*Chesapeake & Ohio, between Richmond, Va., and Clifton Forge, Va.
*Chicago & Alton, between Chicago, Ill., and St. Louis, Mo.
*Chicago & Eastern Illinois, between Chicago, Ill., and Evansville, Ind.
*Chicago & Erie, between Chicago, Ill., and Salamanca, N. Y.
*Chicago & North Western, between Chicago, Ill., and Omaha, Neb.
*Chicago, Burlington & Quincy, between Chicago, Ill., and Omaha, Neb.
*Chicago, Indianapolis & Louisville, between Chicago, Ill., and Louisville, Ky.
*Chicago, Milwaukee & St. Paul, between Chicago, Ill., and St. Paul, Minn.
*Chicago, Rock Island & Pacific, between Chicago, Ill., and Omaha, Neb.
*Chicago, St. Paul, Minneapolis & Omaha, between Minneapolis, Minn., and Omaha, Neb.
*Cincinnati, New Orleans & Texas Pacific, between Cincinnati, Ohio, and Chattanooga, Tenn.
*Cleveland, Cincinnati, Chicago & St. Louis, between Cleveland, Ohio, and St. Louis, Mo.
Colorado & Southern, between Wendover, Wyo., and Denver, Colo.
*Delaware & Hudson, between Wilkes-Barre, Pa., and Albany, N. Y.
*Delaware, Lackawanna & Western, between Hoboken, N. J., and Buffalo, N. Y.
Denver & Rio Grande Western, between Denver, Colo., and Ogden, Utah.
El Paso & Southwestern, between El Paso, Tex., and Tucson, Ariz.
*Erie Railroad, between Jersey City, N. J., and Buffalo, N. Y.
Florida East Coast, between Jacksonville, Fla., and Key West, Fla.
Fort Worth & Denver City, between Texline, Tex., and Ft. Worth, Tex.
Grand Trunk Western, between Chicago, Ill., and Port Huron, Mich.
*Galveston, Harrisburg & San Antonio, between El Paso, Tex., and Houston, Tex.
*Great Northern, between St. Paul, Minn., and Glasgow, Mont.
Gulf & Ship Island, between Jackson, Miss., and Gulfport, Miss.
Gulf, Colorado & Santa Fe, between Galveston, Tex., and Purcell, Okla.
Gulf, Mobile & Northern, between Jackson, Miss., and Mobile, Ala.
Hocking Valley, between Toledo, Ohio, and Columbus, Ohio.
Houston & Texas Central, between Houston, Tex., and Denison, Tex.
*Illinois Central, between Chicago, Ill., and Memphis, Tenn.
International-Great Northern, between Laredo, Tex., and Longview Jct., Tex.
*Kansas City Southern, between Kansas City, Mo., and Texarkana, Tex.
Kansas, Oklahoma & Gulf, between Denison, Tex., and Joplin, Mo.
Lehigh & New England, between Swartswood Jct., N. J., and Campbell Hall, N. Y.
*Lehigh Valley, between Jersey City, N. J., and Buffalo, N. Y.
*Long Island, between Jamaica, N. Y., and Montauk, N. Y.
Louisville & Nashville, between Louisville, Ky., and Birmingham, Ala.
*Louisiana & Arkansas, between Hope, Ark., and Alexandria, La.
Louisiana Western, between Lafayette, La., and Vinton, La.
Louisville, Henderson & St. Louis, between Evansville, Ind., and Louisville, Ky.
Maine Central, between Portland, Me., and Bangor, Me.
Midland Valley, between Wichita, Kan., and Fort Smith, Ark.
*Michigan Central, between Chicago, Ill., and Detroit, Mich.
Minneapolis & St. Louis, between Minneapolis, Minn., and Peoria, Ill.
Minneapolis, St. Paul & Sault Ste. Marie, between Chicago, Ill., and Minneapolis, Minn.
Missouri, Kansas & Texas, between St. Louis, Mo., and Denison, Tex.

Missouri, Kansas & Texas Railway Company of Texas, between Denison, Tex., and Galveston, Tex.
*Missouri Pacific, between St. Louis, Mo., and Herington, Kan.
Mobile & Ohio, between Mobile, Ala., and St. Louis, Mo.
Nashville, Chattanooga & St. Louis, between Nashville, Tenn., and Atlanta, Ga.
*New York Central, between Albany, N. Y., and Cleveland, Ohio.
*New York, Chicago & St. Louis, between Chicago, Ill., and Buffalo, N. Y.
*New York, New Haven & Hartford, between New York, N. Y., and Providence, R. I.
New Orleans Great Northern, between Jackson, Miss., and New Orleans, La.
New Orleans, Texas & Mexico, between Sabine River, La., and New Orleans, La.
Norfolk Southern, between Norfolk, Va., and Raleigh, N. C.
*Norfolk & Western, between Roanoke, Va., and Columbus, Ohio.
*Northern Pacific, between St. Paul, Minn., and Mandan, N. Dak.
Northwestern Pacific, between Sausalito, Cal., and Eureka, Cal.
Oregon Short Line, between Pocatello, Idaho, and Huntington, Ore.
*Oregon-Washington Railroad & Navigation Company, between Portland, Ore., and Pendleton, Ore.
*Pennsylvania Railroad Company, between Philadelphia, Pa., and Pittsburgh, Pa.
*Pere Marquette, between Grand Rapids, Mich., and Detroit, Mich.
*Philadelphia & Reading, between Philadelphia, Pa., and Harrisburg, Pa.
*Pittsburgh & Lake Erie, between Pittsburgh, Pa., and Brownsville, Pa.
*Pittsburgh, Cincinnati, Chicago & St. Louis, between Pittsburgh, Pa., and Indianapolis, Ind.
Rutland Railroad, between White Creek, N. Y., and Rouses Point, N. Y.
*St. Louis-San Francisco, between Springfield, Mo., and Tulsa, Okla.
St. Louis Southwestern, between St. Louis, Mo., and Texarkana, Ark.
Seaboard Air Line, between Richmond, Va., and Jacksonville, Fla.
*Southern Pacific, between Oakland, Cal., and Los Angeles, Cal.
*Southern Railway, between Washington, D. C., and Atlanta, Ga.
Spokane, Portland & Seattle, between Spokane, Wash., and Portland, Ore.
Texas & Pacific, between Dallas, Tex., and El Paso, Tex.
*Union Pacific, between Omaha, Neb., and Cheyenne, Wyo.
Virginian, between Norfolk, Va., and Roanoke, Va.
Wabash, between East St. Louis, Ill., and Buffalo, N. Y.
*Western Maryland, between Baltimore, Md., and Cumberland, Md.
Western Pacific, between San Francisco (Western Pacific Mole), Cal., and Salt Lake City, Utah.
Yazoo & Mississippi Valley, between Memphis, Tenn., and New Orleans, La.

*Roads named in original order.

The order provides that the installations be made in accordance with the specifications and requirements prescribed by the commission in its order of June 13, 1922, and that each of the carriers shall submit to the commission complete and detailed plans and specifications for the installation of the devices at some time prior to the installation thereof.

It is further ordered that each of the carriers shall file with the commission on or before May 1, 1924, complete plans of the signal systems in use on the designated portion or portions of line, and report the number and type of locomotives assigned to or engaged in road service thereon; each carrier shall proceed without unnecessary delay to select and install the devices as specified herein; and that each carrier shall file with the commission on or before May 1, 1924, and on the first day of every month thereafter, full and complete reports of the progress made with reference to the installation of such device or devices under this order.

Each installation made pursuant to this order will, when completed, be subject to inspection by and the approval of the commission or any division thereof to which the matter may be referred.

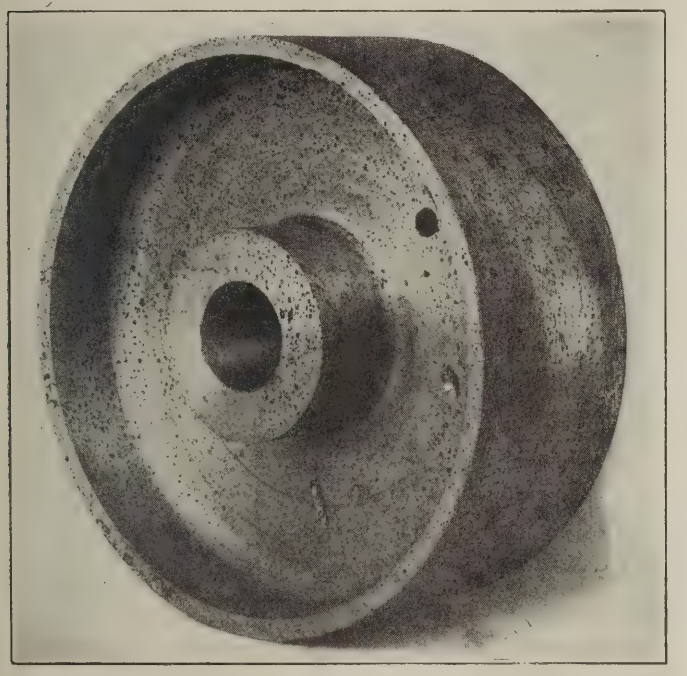
Keystone

On the New York Central Main Line in Central New York State

Possibilities and Limitations of Electric Welding*

The Welders' Opinion of How the Various Kinds of Electric Welding Should be Used

THERE was a time when the wearing of a fraction of a cubic inch of metal from one of the wearing surfaces of a piece made it necessary to scrap the part with a consequent loss of material and labor investment. It was only after the introduction of the fusion welding processes that it became possible to stop this economic waste. By spending a few dollars for welding it is sometimes possible to save parts involving many hundreds of dollars, not only by reclaiming the worn parts,



Solenoid Brake Wheel Manufactured from Cast Steel, Showing Flow Holes in Casting After Being Turned Down, Resulting in the Manufacture of This Wheel by the Automatic Arc Welding Process

but in savings due to the much less time required for welding than for replacing them by new ones.

The repair of broken members of machines has been another important engineering achievement made possible by the electric, gas and thermit processes. Here, again, there are instances every day where the returns on the money spent in welding are as high as 1,000 per cent as compared with replacing these broken parts by new ones.

Of recent years there has been a strong tendency towards substituting castings made of steel for those made of cast iron. The reasons for this are that the steel castings for the same strength are lighter and less brittle and consequently less likely to break under shock. But, steel castings are more liable to defects such as blowholes than are cast iron ones, and as their cost is higher any process that can reclaim steel castings is of great benefit to the manufacturer. Welding processes are used very largely for this purpose, and have resulted in material saving and doubtless in the extension of the use of steel castings in place of cast iron because of the reduction in cost effected by welding processes.

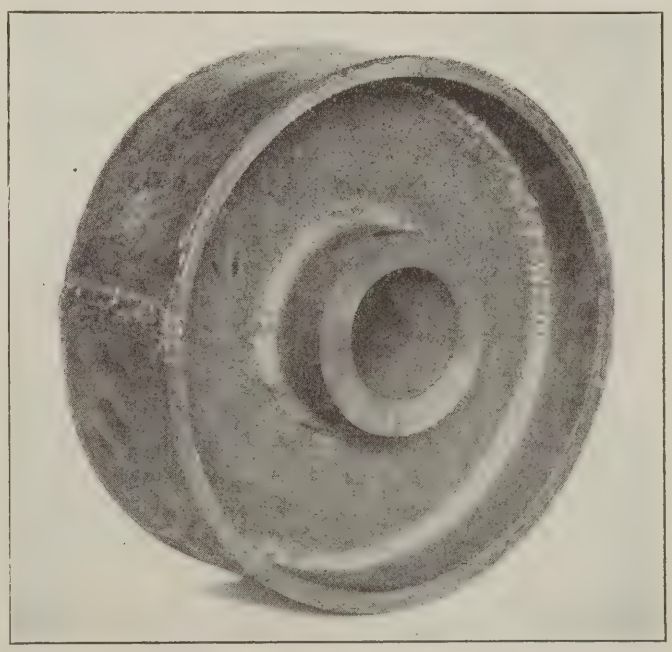
Very often mistakes are made in machining, and were it not for welding these valuable castings would be rendered useless. As it is, the only loss is the time and money necessary to deposit new metal by one of the welding processes. Here, again, the returns on the welding investment may be as high as several thousand per cent.

Possibilities of Welding as a Fabricating Process

The manufacturing process of building a large structure by riveting consists of the following:

1. Design.
2. Making drawings.
3. Making templets.
4. Marking steel.
5. Punching or drilling holes.
6. Assembly.
7. Riveting.
8. Painting in shop.
9. Erection.
10. Painting in the field.

At the present time there would be very little saving in the time taken to design a welded structure as compared



Solenoid Brake Wheel Manufactured from Stock Steel Parts Joined Together by Automatic Arc Welding Process

with a riveted one. This is due largely to the fact that in most cases both would involve the same kind of stress determinations. However, a shop drawing of a riveted structure requires a great deal of time and entails a large expense for practically every dimension is indicated on the drawing, every rivet is carefully located and the size, width and length of every structural shape is given. The amount of work involved is readily estimated when one considers that in a very simple small plate girder railroad bridge there are about 6,000 rivets. A very small fraction of this time would be needed in preparing working drawings for a welded structure.

After the drawings are finished for riveted work, they

*Abstract of paper prepared by the Meetings and Papers Committee of the American Welding Society for the fall meeting of the society, held at Pittsburgh, October 24-26, 1923.

are sent to the templet shop where full size templets made of wood or heavy leather board are prepared for each and every piece in such a way that all holes to be finally placed in the steel are indicated in position and size on the templets. These templets are then sent into a shop where they are clamped to the steel, and each steel piece is marked to conform to its duplicate both as to size, shape and location of all holes. These pieces of marked steel are then passed through shearing machines, shearing them to shape and through punches to punch holes. The numerous pieces which make up the girder or other members and which have been cut to shape and punched are now assembled and temporarily bolted together with a few bolts —all the parts and pieces of steel which are in contact having been given a coat of paint.

In contrast to the work involved in riveted structures outlined in the above paragraph, all of it is omitted in the welded structure.

The assembled members, if they are to be riveted, are taken to the riveting machines either fixed in position, in which case the piece to be riveted must be moved in order to bring the rivet in the proper position in the riveting machine or the riveter is portable for use on heavy work, and is so arranged that it can be moved about as the rivets are driven. In driving rivets it is frequently found that because of inaccuracy of workmanship holes do not come exactly opposite but by driving a drift pin the holes are more nearly brought in line before a rivet is driven. Most of the holes in structural steel work are punched, and after being assembled are then reamed to get a smoother and larger hole. On heavier materials or parts where the best results are desired, holes are drilled.

Again, in contrast to the above, in the welded structure the parts to be fastened are held together temporarily by

Frame Structures Made of Scrap Pipe by Welding. This Money-Saving Application of Welding Has Been Used in Many Sections of the Country for Many Types of Small Buildings

small "tack welds," requiring only a minute or two to make, or by suitable clamps. There are no holes to align, and welding progresses steadily from one end of the seam to the other.

As a general proposition, the riveted or bolted joint has a tensile strength considerably less than the original piece, whereas the welded joint may be made as strong as the original section. Moreover, the welded joint is oil and watertight up to its breaking point, while the riveted and caulked joints leak badly at as low as 25 per cent of the ultimate strength.

Everything considered, it is conservative to state that in most cases the fabrication of steel by welding can be done with a saving of 25 per cent over that of the riveting and with a better quality of product. A saving may not be effected in the first structure, but will undoubtedly be brought about as familiarity with the process and its use is attained by designers, draftsmen and workmen. It should be also pointed out that in some instances the superiority of the finished product would justify the use of welding even though it cost several times that of riveting. A striking example of this is in the construction of oil storage tanks for lighter oils. The present riveted structure is not sufficiently tight for holding these oils, and the savings

Cast Steel Truck Welded for New York Subway

which would be effected by prevention of the loss of oil from leakage and evaporation would in two years pay entirely the cost of the welded tank. Welding has also recently been used in the fabrication of some large gas holders with a saving in cost and improvement in quality of product.

Arc Welding

Steel companies with vision are already preparing for the time when arc welding will supplant the rivet, and they are gaining experience in its use upon the smaller welded sections, or in minor operations which do not require approval. A multitude of minor structural firms, and many large ones, have to their great advantage adopted this new tool, as in the automotive industry, the iron and steel works of the country, the engineering and contracting companies, the steam and plumbing industry, including the laying of steam, water and other pipe lines, as well as the two industries that did most to develop the process—the shipbuilding and railway companies.

To the railway companies belongs the credit for sponsoring arc welding in its infancy. Some of these companies have made use of the process for more than 15 years, chiefly as a repair utility, and a detailed list of the specific uses to which it has been put would occupy a volume of its own. As experience shows conclusively that joints stand up without failure, more and more of the fireboxes on new locomotives are being welded. It is the standard practice on many railroads to weld all the flues in the firebox end when the locomotive is built and when they are reset. While these flues would, under constant service, ordinarily begin to leak in about three months, they have withstood leakage for three years when welded.

When the war came, and brought with it the necessity of great increase in speed and efficiency in shipbuilding, electric arc welding was provided with a chance to demonstrate its worth. That it came up to all expectations is now but a matter of record. The shipbuilding industry took over the process as developed by the railroads, and, under the pressing necessity of the nation's need, developed it to a high degree of perfection. This was especially the case in the working out of the fabricated ship idea.

As far as production is concerned there is probably no metal trade or business that will not ultimately come to use arc welding methods, while, for repair work, there is a use for this process everywhere.

In the beginning, the steel industry rather shied at the

One Piece Welded Storage Tank, 120 in. in Diameter, by 40 ft. Long, Built of Welded Construction Throughout. No Seams, nor Joints, nor Rivets. Manhole and All Connections Welded Solid to Shell of Tank

brilliant light of the arc, and maintained that it could recast broken parts more cheaply than to weld them. Now the recasting is done locally by the aid of the arc. Why recast an entire piece, when you only need to recast the metal around the break or defect?

It was obvious logic, and as soon as it was shown that it could be done the steel companies acquired many machines for the purpose.

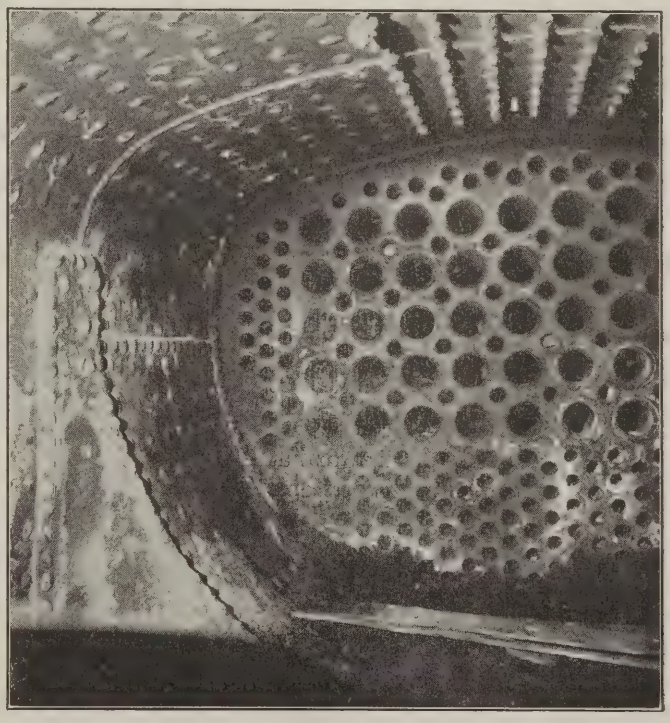
There is not a steel mill now in which arc welding is not well known, and the most difficult jobs have been easily and satisfactorily accomplishd by its aid. They include the padding-up of worn wobblers which are hardened and smoothed at the same time by the use of the carbon arc; water-cooled fire-door repairs; repairs of bearing breakages and rolling stock; repairs from wear and accident, including special locomotive jobs; repair of miscellaneous breakage and wear such as broken gear teeth, worn keyways, worn armature shafts, misdrilled holes and lack of bosses, in short, a multitude of jobs that can be handled by a "putting-on" tool.

Electric Arc Cutting

Although it is common practice in the steel industry to use gas for cutting, yet there are many places where the electric arc may be used advantageously because of the resulting saving in cost. Arc cutting may be defined as a resultant combination of the melting of metal due to its high temperature, and the oxidation of a portion of this metal by the oxygen of the air. This oxidized portion, because of its lower melting point, acts as a lubricant and tends to slide off the greater masses melted by the heat of the arc.

In arc cutting, gravity must be utilized in that the operation must be performed from the vertical or underside. Many attempts have been made to use oxygen or air under pressure with arc cutting, but it has so far been found impractical to do this. However, the intermittent use of compressed air or oxygen with the arc has been made successful by releasing a stream of air after the arc has made the puddle molten, and by blowing it away upon the oxide lubrication. This method is especially useful in rivet cutting on a top or horizontal surface.

This arc will cut any metal, viz., brass, copper, zinc, lead, cast iron, malleable iron, high carbon or alloy steels, etc. Considering the supply of heat energy necessary, the electric arc process is also cheaper than gas. Yet, for heavy work, the use of the gas method is the best practice because of the speed possible. Moreover, for heavy and careful work, gas can equal machining methods, for which the electric arc cannot be considered. For rough work, however, such as cutting up scrap into charging sizes, or for work requiring subsequent machining, the electric method is the cheaper, providing the thickness of the piece is not too great. For cutting non-ferrous metals, the arc is thus far superior. The arc will efficiently cut the scrap sections of cars, boilers or tanks into charging sizes, and will rapidly cut through sills, channels, or other stiffening



Upper Half of Locomotive Combustion Chamber, Showing Butt Weld on Crown Sheet and Caulking Weld on Side Sheet of Combusion Chamber, All Superheater Pipes and Flues Electrically Arc Welded to Fue Sheet

members at a rate proportionate to their thickness, but always at the same low cost of power.

For straight arc cutting, the thickness that can be economically cut by the arc is under six inches, and lies between two inches and six, depending upon the price of power and other considerations. For heavier sections, the speed of gas cutting is greater than that of arc cutting, and is the cheaper because of smaller labor costs. There is, however, a method of nicking and breaking in which the electric arc is more efficient than gas for any size

material. In any average scrap pile, the work is more economically done by the electric arc; the heavier sections may be nicked and broken, or cut through with gas.

A striking example of economy is found in rivet cutting by the arc. One man with the arc (where power cost is very small) will cut from one hundred to two hundred rivets an hour.

Resistance Welding

Resistance welding is used in the manufacture of many articles we use every day, including the welding of the stems in watches, the rims of our eye-glasses, the handles of knives and forks, the rims and frames of our baby carriages, our automobiles, rims for truck wheels, handles on wrenches, chisels and hayforks, shanks of mild steel on high-speed drills, reamers and cutters, chains for all purposes and of all sizes. The term, "resistance welding" applies to seam welding, spot welding and also to butt welding.

Seam welding has now been developed so that two ⅛-inch sheets may be successfully welded and the length of seams can be practically anything that can be secured in commercial stock. It can be applied to the manufacture of steel barrels, casks, tanks, culverts, smoke-stacks, ventilators, conveyor tubes, heating and ventilating pipes, etc. The seams can be made at the rate of 40 ft. per min. on two 1/16-in. sheets and 20 ft. per min. on two ⅛-in. sheets without any previous scarfing or special preparations of stock.

"Spot welding" machines have now been developed that are entirely automatic as regards time and pressure so that the welder functions in the same way each time, and makes all welds alike. One electrode is stationary while the other slides on a carriage which is moved up and down by a revolving cam. A coil spring between the electrode and carriage insures uniform pressure of the work piece and the speed of the cam is such that the electrode is in contact with the work just long enough to secure good fusion of the pieces, probably one or two seconds. A commercial spot welder has now been developed for welding two plates of a thickness of one-half inch.

Through the application of butt welding, steel castings or complicated machine parts are being replaced by either drop forgings or steel stampings in halves and welding these halves together by the resistance method. By this procedure great uniformity of product and light weight may be obtained and while retaining or improving the quality, articles so manufactured can be produced much cheaper.

The resistance welding is distinguished from other welding processes in that it is used particularly for mass production of standard articles to be brought to welding machines to be welded, mostly by semi or total automatic means, excluding as much as possible the individual skill of the operator.

The range in size and composition of articles to be thus welded is very great. Wires as small as electric light filaments can be welded as a minimum. Iron or steel articles from 16 to 20 sq. in. cross section are successfully welded as a maximum, and the size and quality of product desired will determine whether it will be more economical to weld in a step-by-step fashion by a small amount of energy extended over a long time as in seam welding and spot welding, or to apply a large amount of energy over a great area for a short time only.

Detecting Flaws in Iron and Steel

RAPID developments have been made recently in effecting practical methods for determining the character of iron and steel by magnetic test. The method cannot be used as a substitute for chemical analysis, but disclosures just made by Dr. Chas. W. Burrows indicate that it will find extensive commercial application. The Pennsylvania and the New York Central, in conjunction with the Bureau of Standards and the American Society for Testing Materials, have taken a part in the development work.

Dr. Burrows was formerly in charge of the magnetic section of the U. S. Bureau of Standards and is now associated with the Burrows Magnetic Equipment Corporation, Jersey City, N. J., a subsidiary of the Federated Engineers' Development Corporation. Magnetic analysis as demonstrated by Dr. Burrows is particularly useful for comparing the quality of pieces of metal of uniform size and shape with a standard piece of known quality. In this way slight differences in heat treatment or quality can be detected. The operation is a simple one which can be applied semi-automatically without the aid of technical experts. Similarly, variations in the character of metal in spots in long pieces of uniform section, such as a rail, can be detected with great accuracy. In making these tests, it is necessary that the cross section of the pieces tested be uniform, but slight variations in commercial shapes will not affect the value of the test.

Following a slightly different method of procedure, an arbitrary standard or scale can be set up and the degree of hardness of a number of pieces of metal can be compared, even though the sections may vary considerably.

Up to date, commercial applications have been limited to a machine which has been used for two years by the General Electric Company for testing steam turbine bucket discs, a machine which is about to be delivered to the Hyatt Roller Bearing Company for testing bearing stock and a machine ordered by the Ford Motor Company for testing automobile bevel ring gears. The General Electric machine has demonstrated its value and the purchase of the other two may be considered an indication of faith in the success of the method. The value of such a method as applied to the testing of rails, wheels or boiler plates for flaws, axles for degrees of heat treatment or flaws, staybolt iron for uniformity, etc., is obvious.

On the Tampico-San Luis Potosi Branch of the Mexican National

New L-5 Type of Electric Locomotive Built by the Pennsylvania Railroad and Equipped by the Westinghouse Electric & Manufacturing Company

Steam and Electrical Men Get Together

Requirements of Electrical Equipment Outlined by Representatives of Various Railroads

A TRANSPORTATION meeting on Tuesday, February 5, was a feature of the twelfth mid-winter convention of the American Institute of Electrical Engineers held in Philadelphia, Pa., February 4 to 8. The afternoon session was devoted to a semi-technical discussion of electrification and allied subjects while the evening program was given over to the presentation of the railroad problem as a whole in five brief addresses. The evening meeting was broadcast from radio stations in New York City, Schenectady, N. Y., Philadelphia, Pa., and Pittsburgh, Pa.

Performance and Design of Locomotives

The afternoon meeting was opened by Professor Harris J. Ryan, president of the Institute. Professor Ryan introduced N. W. Storer of the Westinghouse Electric & Manufacturing Company who presided during the presentation of papers and subsequent discussion. The first speaker was L. G. Coleman, assistant general manager, Boston & Maine. Mr. Coleman read a paper in which he stated that there is lots of lost motion in railroad operation, a remedy for which has not yet been evolved. Large improved types of locomotives, he said, economize fuel and increase railroad capacity but they also introduce other factors which increase what may be termed lost motion. Under similar service conditions old and simple types of locomotives were available for service 75 per cent of the time, while modern locomotives are available for service only about 45 per cent of the time. The cost of maintaining locomotives is now about four times what it used to be; this sacrifice is made to obtain greater operating efficiency. Years ago, he said, 65 per cent of the motive power was ready to turn when it arrived at the terminal. Now, in his opinion, probably not more than 10 per cent can be turned until minor repairs have been made. Lengthening divisions has reduced this lost motion to a certain extent, but quicker turning must be had. The field, he maintained, is open for electrification, but there is need for standardizing electrical equipment and reducing its cost.

The second speaker was J. E. Crawford, assistant general manager, Norfolk & Western. Electric operation on the Norfolk & Western, he stated, was considered first only as a pusher service, but a study showed that a distance of 30 miles between and including an assembly yard and a classification yard should be electrified. Comparative cost figures are difficult to obtain as the section electrified does not include a whole division, but according to the best calculations, electrification has effected a saving of about 8 per cent in operating costs. The cost of repairing and maintaining the locomotives is also difficult to determine and the high cost during past years has been caused by the locomotives being built without precedent and the corresponding need for considerable redesigning. Mr. Crawford also pointed out the fact that the actual cost of repairs in 1922 on a basis of tractive effort was 37 per cent greater for steam locomotives than for electric.

Electric locomotives, he said, should make about twice the mileage that steam locomotives make, but past performances show something less than this as there were eleven locomotives available when eight could do the work. The mallet locomotives used on the division are available for service about 50 per cent of the time, while the electrics were available 85 per cent of the time. Electric locomotives, he said, cost, pound for pound, about twice as much as steam, this being true for the locomotives placed in service in 1915 and also for those purchased in 1923. Fuel economies made by the electric locomotives he estimated to be from 25 to 30 per cent. Regenerative braking is of great assistance in handling heavy trains. In summing up, Mr. Crawford said that delays due to failures are reduced because of reduced

damage to equipment by rough handling; economies have been obtained principally by the fact that electrification of the section has increased the capacity of the whole road. It is the intention of the road, he said, to extend the electrified section eventually to include the whole division.

What the Electrical Engineers Must Do

N. D. Ballantine, assistant to the president, Seaboard Air Line, said he was impressed with the lack of correlated information covering electrification and stated that in compiling such information it was essential to remember that railroads are built to take care of peak demands. The chairman, Mr. Storer, supplemented this by asking what the railroads are looking forward to in the way of further increasing drawbar pull and improved methods of handling trains.

Mr. Crawford replied that they were looking forward to the use of steam locomotives for a long time to come and that he hoped there was no limit to the possible developments. At the present, there are definite limitations imposed by weight of bridges, weight of rail, length of passing tracks, classification yards, etc. Speed of freight trains in his opinion could be increased to 50 miles an hour.

A. H. Babcock, electrical engineer, Southern Pacific, told how steam power was used on the Southern Pacific to meet difficult operating conditions and offered the opinion that heavy fixed charges block the economy of electrification. He said also that second track must be had by many roads before they will consider electrification because of the great desirability of second track for preventing all kinds of delays. He cited one instance where one steam locomotive made a continuous run of 815 miles. Not including terminals, tunnels and "bottle necks," like the Norfolk & Western, he said, "Show us one electrified property that is making any money."

W. S. Murray, consulting engineer, replied to this challenge by stating that there was no such property because there was no complete installation of electrification anywhere. The New York Central, he said, is a switching service and not a trunk line, while the New Haven has not been able to take advantage of its electrification because it could not afford to purchase needed additional locomotives. The St. Paul because of its long line and few trains could not be expected to show a profit. There are many sections of railroad, he said, which if electrified would undoubtedly show economies. He also questioned the statement made previously that steam locomotives are available for service 45 per cent of the time. Mr. Storer then asked if any one present could present a picture of the problem and outline the several conditions to be met.

William Elmer, division superintendent, Pennsylvania, replied to several of the questions which had been raised. Couplers, he said, have been designed and redesigned many times and he expressed the opinion that for many years to come there will probably not be much change made in an effort to increase either the strength of couplers or car underframes. Strength of bridges, he said, will probably not be greatly increased. He showed how trains can be so long that the crews cannot operate them efficiently and offered the opinion that a 100-car train represented about the practical limit. While 125 and 150-car trains can be used successfully under a few special conditions, too long trains cause unnecessary delays. He stated that he did not think that a speed as high as 50 miles an hour was practicable with heavy type freight cars; also that increased speed over a division will not reduce wages although it may effect other economies.

With regard to the availability of steam locomotives he referred to figures compiled during federal operation which showed that steam locomotives over a given period of time made 56 miles a day. If the average speed was 10 miles an hour, he said, this represented a little less than 25 per cent availability or less than that if they went faster. He concluded by expressing the opinion that when 50 per cent of the locomotives on any railroad make 3,000 miles per month, they are giving good performance.

Evening Meeting

The evening meeting dealt with politics and the general railroad problem. The subjects and speakers were as follows: "Place of Transportation in Civilization," by E. G. Buckland, vice-president, New York, New Haven & Hartford; "Credit Question in Transportation," by Francis H. Sisson, vice-president, Guarantee Trust Company of New York; "Transportation and the Rural Situation," by Ralph Budd, president, Great Northern; "The Public's Transportation Problem," by H. B. Thayer, president, American Telephone & Telegraph Company; "Solid Foundations for Better and Cheaper Transportation," by Albert J. County, vice-president, Pennsylvania Railroad.

Motive Power Exhibit

The Pennsylvania Railroad held a motive power exhibit at West Philadelphia in connection with the meeting. It included the latest types of steam and electric locomotives, multiple-unit electric cars and a gasoline rail car. The equipment shown represented an investment of about $750,000.

Two electric locomotives were exhibited which have contrasting characters. One, which is designated as Pennsylvania Class "FF-1," has the distinction of being the most powerful single unit electric locomotive ever constructed for any railroad in the world. The "FF-1" has been designed for heavy, slow speed freight service. It weighs 516,000 lb. and is capable of exerting a starting tractive effort of 140,000 lb. At a speed of 20 miles an hour it is capable of producing continuously a tractive effort of 73,000 lb. This locomotive was built by the Pennsylvania at its Altoona Works and equipped by the Westinghouse Electric & Manufacturing Co.

The other electric locomotive is known as Pennsylvania Class "L-5." It was designed to be, as nearly as possible, a general utility locomotive, representing a standardized type which can be utilized with high efficiency and economy under almost any operating conditions and in any form of service, except switching. The construction is such that simply by a change in the gear ratios between the motor and the wheels it can be converted from a freight to passenger locomotive, or vice versa. Its electrical features have been so planned that by changing the control apparatus, it can be operated either with alternating or direct current. The "L-5" weighs 408,000 lb. When geared low for freight service it develops a starting tractive effort of 100,000 lb., and at a speed of 23 miles an hour will produce a continuous tractive effort of 50,000 lb. When geared for passenger service it has a starting tractive effort of 54,000 lb., and when running at 46 miles an hour, or standard average express

speed, it will develop continuously a tractive effort of 25,000 lb.

The five steam locomotives exhibited included all requirements of steam railroad service except switching. Two freight locomotives were shown, one being of the Class "I-1s," the Pennsylvania standard heavy freight locomotive. In working order it weighs, with its tender, 582,100 lb. It has 62-in. driving wheels and develops a starting tractive effort of 90,024 lb. This particular locomotive was built at the Baldwin Locomotive Works from Pennsylvania Railroad design. A large number of these locomotives were also built at the Altoona Works.

The other freight locomotive shown was of the Mallet articulated type known as class "HC-1s." This locomotive is intended only for push service. Its use is confined to helping trains on the east and west slopes of the Allegheny mountains. It also has 62-in. driving wheels, and weighs in working order and with its tender, 805,500 lb. It develops 135,000 lb. starting tractive effort.

The other three steam locomotives embraced in the exhibit were all for passenger service. One is the newly designed Class "M-1," a mountain type locomotive intended for through express passenger service where maximum power is required. This locomotive is also adaptable for fast through freight service, such as the handling of perishable and other preference freight trains over long hauls. It has 72-in. driving wheels, develops 64,550 lb. starting tractive effort and weighs, with tender, 559,600 lb. It was designed and built at Altoona.

The second of the passenger locomotives which was shown is of the Pacific type and is known as class "K-4s." It has 80-in. driving wheels, a starting tractive effort of 44,460 lb. and a weight, with tender, of 467,890 lb. It is the Pennsylvania standard for heavy through passenger service and answers the requirements of all trains of that character except those for which the extreme power of the "M-1" is needed. It was constructed at Altoona.

The third passenger locomotive exhibited is known as class "G-5s." It is a medium weight locomotive intended for heavy local passenger service where great tractive effort is necessary in order to gain speed rapidly in starting, thus making it possible to maintain high average speed over accommodation runs where many stops are made. It has 68-in. drivers, develops 41,328 lb. starting tractive effort and weighs 413,500 lb. It was designed and built at Altoona.

Supplementing the seven engines, two other types of motive power were embraced in the exhibit. One is the multiple unit electric passenger coach, now standardized for suburban electric service, such as that rendered in the Philadelphia district on the electrified portion of the main line and the Germantown and Chestnut Hill branch. It seats 72 passengers, weighs 118,600 lb., operates from either end, and was built from the standard design of the railroad.

The other is a gasoline rail motor car, designed and built by the J. G. Brill Company, of Philadelphia, for use on railroad branch lines where the traffic is too light to support steam service or warrant electrification. The Pennsylvania Railroad is now operating several cars of similar type on various branches. It is 42 ft., 8 in. in length, weighs 30,000 lb., seats 38 persons in the passenger compartment and has a baggage compartment 11 ft. 3 in. in length, with emergency seats for eight passengers.

Electric Lighting for Railway Cars*

Intensity of Illumination Dependent Upon Type of Car and Upon the Amount of Energy Available

THE special conditions surrounding the generation of light, and its application for obtaining correct illumination of car lighting, differentiate it considerably from other forms of lighting and illumination.

The amount of energy which can be used for lighting is limited. This energy can be obtained from a stored supply, or it may be generated on the car itself, which also entails obtaining it at times from a stored supply. This limitation in the amount of energy available makes its most efficient utilization necessary.

The lighting fixtures must be permanently secured in position, and out of the way of seats, baggage racks, and sleeping car berths, and their position is also determined by the actual conditions of car construction. This limits the flexibility possible in placing the units.

The problem is further somewhat complicated by the fact that the fixtures must be maintained with the minimum of labor expended in their upkeep, and as the conditions on a railroad car are particularly bad as regards the collection of dust and dirt on the fixtures, this item is one which has had careful study in the designing and placing of the lighting units.

Electric Lighting

A large proportion of the new cars now being built are fitted with electric light. In some cases, electric light is also being applied to older cars, displacing the former systems.

The axle generator system is almost exclusively used for generating the electricity for lighting cars.

The system known as the *straight storage system* was formerly used to a considerable extent, but it has almost entirely disappeared. With this system, the light was obtained from storage batteries which were charged at a stationary plant, necessarily while the car was not in operation. This system has gone out of use, because the time required for charging the batteries lessened too much the availability of the cars for actual service, as it required an actual charging period of eight hours to properly charge the batteries.

Some trains are still lighted by the *head end system,* in which the current is obtained from a steam driven gen-

*An abstract of a paper presented before the annual convention of the Illuminating Engineering Society, by Geo. E. Hulse, Chief Engineer, Safety Car Heating & Lighting Co., New Haven, Conn.

erator in the baggage car of the train. This generator supplies the current for the whole train. A few of the cars in the train were supplied with storage batteries to take care of the lighting during such times as the engine was detached. This system, however, is going out of use. In the winter time the steam used by the turbine is too much of a drain on the locomotive, which, at certain times, needs all the steam supply which it can generate to pull the train. This system is also quite inflexible, as it provides no means of lighting cars which may be detached from the train and sent to branch lines.

In the axle generator system, the current is generated by a dynamo driven from the axle of the car. This dynamo provides current for the lights, and charges a storage battery which provides current for lighting when the car is not in motion. With this system, each car is its own power plant, which is in operation whenever and wherever the car may be in service. Such attention as is necessary for the proper operation of the system may be given to the car during the time of its regular layover periods.

The essentials of such a system are as follows:—(1) A generator mounted on either the car body or the truck with some form of driving system between the car axle and the generator. (2) A storage battery to furnish

Dining Car with Center and Side Lighting

current when the car speed is not sufficient to drive the generator at a speed to properly charge the batteries and light the lamps. (3) A regulator to govern the output of the generator at varying speeds, and to properly charge the storage battery and protect it from overcharging. (4) A regulator to maintain proper voltage at the lamps. (5) Some means of keeping the polarity of the generator constant, when the direction of movement of the car changes.

These conditions have been successfully met in various ways, the majority of equipments in use now embodying the following features:—(1) A generator mounted on the car underframe, driven by a belt. (2) The generator is controlled for output at varying speeds by a carbon pile rheostat in its field circuit. (3) The battery is protected from overcharging by the voltage which can be supplied to it being limited to a voltage which will properly charge the battery but will not overcharge it. (4) The lamp voltage is held constant by an automatic carbon pile rheostat.

At present, there is some demand for a drive which will be more positive in its action than a belt. Belts do give some trouble from slipping, and from being lost,

Dining Car with Side Fixtures—Center Illumination from Fixtures on Deck Rail

especially in winter weather. Various types of gears or other positive drives are being investigated, but it is doubtful whether when all the conditions of application to the car, first cost, and the cost of maintenance are considered, the increase in service will be justified.

Car Illumination

I have already said that the mounting positions for the lighting fixtures in railroad cars are limited—in fact, there are practically only two positions in which the fixtures can be placed. These are:—(1) On the upper deck, that is, directly under the roof of the car, or (2) on the side deck. As the ceiling height is only nine feet, it is impossible to keep the light sources out of the range of vision, and makes the screening of all light sources absolutely necessary.

While these limitations may have led to some inconvenience, they have also accomplished the adoption of certain standards for lighting cars, which must be very closely adhered to.

There are standards in use for the illumination of almost every type of car, and these standards are based on

data obtained from tests made in cars with all possible combinations of fixture positions, light sources, and fixture accessories.

Postal Car Lighting Tests

In 1912, the post office department, represented by the railway mail service, together with a number of railroads and manufacturers, conducted a series of tests at Washington to determine what was the proper illumination for postal cars, and how it could best be obtained. These tests included the measurement of illumination with all available arrangements of fixtures, light sources,

Parlor Smoking Car, with Center and Side Lighting

reflectors, and glassware. They also included tests of the amount of illumination necessary for the postal clerks to do their work properly and without eye fatigue. These latter tests were made with a large number of operators, and with all possible combinations of fixture positions, light sources, reflectors and glassware.

As a result of these tests, specifications were issued by the post office department covering completely the lighting of postal cars, as to the general position of the fixtures, and the amount of illumination necessary in different parts of the car, the latter being given a maximum and a minimum value. Differentiation was also made between the different types of reflectors, and where the tests showed that the illumination necessary differed with one type of reflector and another, proper allowances were made in the specifications.

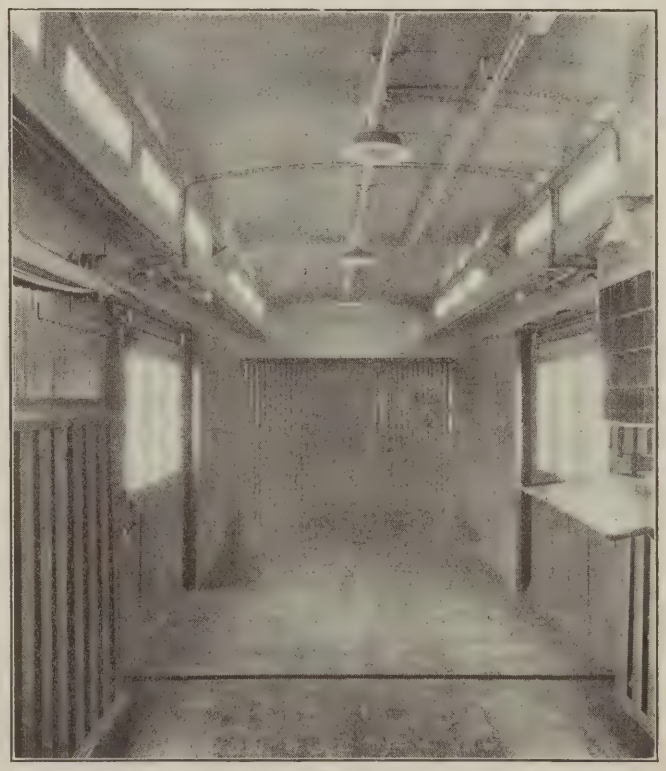
The application of these specifications has resulted in a very satisfactory illumination of postal cars, and although since these tests were made the types of light sources have changed, the interior construction of the car has been modified, and new types of reflectors have been introduced, the information obtained, and the standards adopted as a result of these tests have made it possible to rearrange the illumination and give satisfactory results without the necessity of any further investigation.

Following the postal car tests, a number of railroads and manufacturers interested, conducted a series of tests on the lighting of railroad coaches at Cleveland. In these tests, the amount of illumination with all possible arrangements of fixtures and available types of reflectors and bowls and light sources, was determined. The results of these tests were sufficiently comprehensive to cover all the features which have been introduced in car lighting since that time, and are still in use as a basis for designing the lighting installations in practically all classes of cars, except postal cars.

Type C Lamp

The introduction of the type C lamp with its larger output of light per unit of energy has, of course, had some influence on car lighting where the question of efficiency in the light source is particularly important.

Up to the time of the introduction of the type C lamp, the use of open reflectors was universal for almost all of the different classes of cars. This was used on account of its increased efficiency over any enclosing bowl, and also on account of the fact that it was considerably easier



Baggage Car, Center and Door Fixtures

to keep clean than plain glassware. Indirect lighting has never been used to any extent in car lighting due to the difficulty in keeping the reflecting surfaces in proper condition. The appearance of the fixture with open reflectors is, of course, not so pleasing as fixtures with enclosing bowls, and the proper screening of the light source is considerably more difficult.

Since the introduction of the type C lamp, however, the use of enclosing glassware is increasing, as about the same output per unit of energy used can be obtained by using enclosing glassware with the type C lamp as can

be obtained with the open reflector and the type B lamp, and the appearance of the former type of fixture is considerably better than the open reflector.

Type C lamps are being used to some extent in open reflectors, but this is not good practice, unless the lamp is white glass, or bowl frosted, as, even if the light source itself is screened, the bright reflection spots on the reflector are very trying to the eyes.

Postal Car, Bag Rack Section

The following is an outline of the methods of lighting used in the various types of railway cars:

Coaches

Coach lighting is, of course, of the greatest importance as coaches constitute the largest number of cars in use, and carry more people than any other class of car.

A certain amount of general illumination is necessary, but the principal illumination is required for reading.

Postal Car, Letter Case Section

The lighting system should be designed for best illumination on the reading plane, which is 45° to the horizontal, and at right angles to the centre line of the car. The lighting tests which I have referred to demonstrated that equally good illumination, as far as intensity, distribution and uniformity go, could be obtained either with the fixtures mounted on the upper deck or on the side deck.

Centre lighting is more largely used, however, on account of the fact that it requires less fixtures, and there are fewer lamps and reflectors to maintain. Centre lighting also gives less trouble from shadows cast by the passenger's head on his own or another passenger's reading. The standard spacing for lamps is 6 ft. both for those mounted on the centre deck and on the side deck. The mounting height for the centre lamps is about 8 ft. and for the side lamps 6 ft. 6 ins.

The open-mouth type of reflector, in either heavy density opal glass, or clear prismatic, is employed for coach lighting, preferably with type B lamp. For centre lighting, a 50-watt lamp is used, having an output of 560 lumens, and for the side lighting a 25-watt lamp, having an output of 270 lumens.

Using these lamps, the following illumination values are obtained with the open-mouth reflectors as in Table I.

TABLE I

FOOT CANDLES

	45° PLANE			HORIZONTAL EFFICIENCY	
	Window Seats	Aisle Seats	Mean	Average	Horizontal Plane
Heavy Density Opal	2.87	3.85	3.39	4.95	49.7
Clear Prismatic	2.81	3.67	3.25	4.67	46.6

When type C lamps are used, they should be used exclusively for centre lighting, in fixtures placed close against the ceiling with an enclosing bowl, the mounting height of the fixtures being about 8 ft. 6 ins.

The bowls used are of the best type of transmitting glassware, and the lamps 50-watt type C, with an output of 740 lumens. With the grade of glass now available, the following illumination values are obtained (See Table II):

TABLE II

FOOT CANDLES

45° PLANE			HORIZONTAL PLANE EFFICIENCY	
Window Seats	Aisle Seats	Mean	Average	Horizontal Plane
2.59	2.85	2.72	3.35	22%

Using the 75-watt type C lamp (1,215 lumens, or 202 lumens per running foot of car) these values would be as follows (See Table III):

TABLE III

45° PLANE			HORIZONTAL PLANE EFFICIENCY	
Window Seats	Aisle Seats	Mean	Average	Horizontal Plane
3.58	3.44	3.75	4.65	

It will be noted that using the same wattage the values obtained with the type C lamp and enclosing bowls are about 20 per cent lower than with the open-mouth reflectors. With the enclosing bowl, to obtain illumination equal in intensity to that obtained with a type B lamp and open-mouth reflectors, it is necessary to increase the wattage 50 per cent and to use a type C lamp. With the enclosing bowl there is no danger of glare, and the appearance of the car is considerably improved.

Dining Cars

The evolution of dining car lighting is an example of the fact that the type of lighting which may be satisfactory in one place may not be satisfactory under what appear to be very similar conditions. It is generally conceded that the requirements for dining room lighting are that the table itself should be made a place of high illumination, and that the remainder of the room should be at a considerably lower level.

Some years ago a system of lighting dining cars was designed, based on these requirements, and this system met these requirements fully. However, it did not give

satisfaction to the patrons of these cars. The lighting fixtures were placed directly over the tables, with concentrating reflectors above the lamps, and directing plates under the lamps, placing a high illumination directly on the table. The general illumination was quite low, and was obtained by a few light sources in the upper deck of the car. While the tables were very well lighted, the rest of the car, of course, was not, and patrons of dining cars complained that the cars were gloomy. This has led to an installation, in which there is a considerable degree of general illumination. The lamps over the tables have been retained, but the general illumination is now of a higher value, and is obtained either by semi-indirect lamps or by enclosing bowls placed directly against the ceiling. The lamps for general illumination are mounted 6 ft. apart, and use 50-watt type C lamps. The illumination on the table top is from eight to twelve foot candles, and is obtained by the use of 50-watt type C lamps, mounted in the special fixture referred to.

The kitchens and pantries in the dining cars, of course, require a high degree of general illumination, as they are so small that the work of preparing meals is carried on in all parts of these rooms. The present practice is to light these rooms by ceiling fixtures, using a 50-watt type C lamp with a reflector of the RLM type.

As the work is carried on by the occupants of these rooms in a standing position, and this work is all below the level of the eye, this type of fixture can be used without any bad effects from glare.

Sleeping Cars

Sleeping cars require lighting for general illumination, for reading, or for working at a table in the sections, for the illumination of the berths after they are made up, and for the illumination of the aisle for passengers who go through after the berths are made up.

The fixtures for general illumination must be placed close to the ceiling to prevent interference with the fixture from the upper berth. A shadow enclosing bowl is used with these fixtures.

Small units, with individual control, placed in the corner of each section, provide additional local illumination for reading in the seats, and for the necessary light after the berths have been made up.

The state rooms in a sleeping car and compartment car are lighted by the same type of ceiling lamp as is used in the berth section of the sleeper.

Smoking rooms are lighted by centre lamps in the ceiling, and also may have bracket lamps at the back of the fixed seats to ensure proper lighting for reading.

The passageways are lighted by ceiling fixtures, either with open-mouth reflectors or a fixture having a reflector set into the ceiling, and a directing plate under the lamp set flush with the ceiling.

It was formerly the custom to leave one or more of the centre lights lit after the berths had been made up, but this, of course, was a nuisance to the occupants of the upper berths. Fixtures are now being used which are secured to the frame of the seat. These fixtures throw the light on the floor, making it easy to find the way along the aisle after the berths have been made up, and the ceiling lamps have been extinguished.

For the centre lamps, type C bulbs, 100-watt, having an output of 1,700 lumens, are used. The general illumination on the reading plane with this fixture and 100-watt bulb averages five foot candles. For the berth lamps, 25-watt type B bulbs are used.

Parlor Cars

Parlor cars require illumination mainly for reading purposes, together, of course, with sufficient general illumination. The same type of installation is used in parlor cars as in sleeping cars, with, of course, the omission of the particular units having directly to do with the sleeping car berths.

Parlor-Smoking Cars

These cars require general illumination, and also good illumination on the reading plane. The general illumination is obtained by the same type of centre fixture as is used in sleeping cars, but as the seats are on the side of the car facing the centre, it is necessary to add to this illumination for reading purposes. The additional illumination is obtained either by pendants attached to the side deck, or by brackets on the side walls of the car.

Postal Cars

The proper illumination of a postal car is, of course, very important as postal clerks are employed constantly while in the car on work which demands the best possible illumination.

Postal cars are divided into three sections—

(1) The section where the letters are taken from the sacks and distributed to the pigeon holes according to the route which they are to follow.

(2) The bag distributing rack, where the papers are distributed into boxes, and where packages or letters are placed in the mail bags.

(3) The storage end, where the filled sacks are stored.

The letter distributing cases require high illumination on the vertical plane for the box labels, and on the horizontal plane for the reading of the addresses on the mail.

The bag distributing racks require high illumination on the horizontal plane, for reading the addresses on the packages and also for the labels on the bag rack.

The storage end of the car requires a fair general illumination. The following are the specifications of the railway mail service for the initial illumination values for the various portions of the postal car as in Table IV.

TABLE IV
INITIAL VALUES OF ILLUMINATION REQUIRED

Bag Rack Portion	FOOT CANDLES Minimum	Maximum
Centre of car—horizontal	3.75	12.00
Mouth of bags, measured 18 inches from side of car—horizontal	2.00	12.00
Lettercases		
Over table—horizontal	3.75	19.00
Face of case—vertical	1.66	19.00
Storage portion	2.00	12.00

These initial values are so set as to give adequate illumination in case there is a depreciation of 40 per cent in the efficiency of the installation.

If reflectors with a glazed reflecting surface, such as porcelain enamelled metal, are used, these values must be increased 25 per cent.

The reflector most largely used in postal car lighting is one made from aluminum, with a special matted surface, which gives a high reflecting efficiency, and which may be easily cleaned, and its original efficiency restored.

These specifications are fulfilled in the 60-ft. postal car of the present type, by using 15 type B 50-watt 560-lumen lamps. These lamps are used with an aluminum open-mouth reflector, the reflector at the letter case

being of the intensive type, and those in the bag rack and storage portion, giving the maximum output at an angle of 45°.

If type C 50-watt lamps are used, eleven lamps are required. These lamps have an ouput of 740 lumens. The same type of reflector is employed.

The railway mail service require that if the type C lamp is used, it must be bowl frosted, or enamelled.

Private or Business Cars

The private or business car generally consists of what may be termed the living room, or office, in the observation end, several state rooms, or bedrooms, dining room, and kitchen.

The living room or office is provided with general illumination from centre lights. It may have chairs placed along the side facing the centre, and lighting for reading at these chairs is provided by brackets on the side wall, or pendants on the lower deck. Adjustable local lighting units are provided for the desks and type-writers with which these rooms are generally fitted. There are also local lights provided for lighting the gages and speed indicators which are installed in this room.

The bedrooms may be fitted either with the ordinary form of sleeping car berth, or with a portable bed. These rooms generally have one centre lamp. If there are berths, the berths are provided with berth lights, and the beds have reading lights attached to the bed posts. The mirrors in these rooms are provided with local lighting brackets set on either side of the mirror. The centre lights used are generally of the enclosing bowl type, mounted close to the ceiling.

The dining room is ordinarily lighted by one centre light placed directly over the table. In some cases, the dining room may be also used for a sitting room. In this case, additional lighting is provided by brackets or pendants on the deck rail.

Baggage Cars

These cars must be provided with good illumination both on the horizontal and vertical planes.

The illumination on the vertical plane must be of a good value up to a height of seven feet. Trunks and other articles which are carried in baggage cars are often piled very high in the car, and the illumination must be sufficient so that the labels, or markings, on all baggage can be easily read.

Glass reflectors, or enclosing bowls, are not desirable in this class of car on account of the danger of breakage.

The best practice at present is the use of metal reflectors of the RLM type, placed as close to the ceiling as possible. With such reflectors and 50-watt, 740-lumen type C lamps, spaced 10 ft. apart, an illumination of about four foot candles will be obtained on the horizontal plane, and an illumination varying from one to five foot candles on the vertical plane.

Baggage cars should also be provided with a fixture over each door having a metal reflector designed to light the floor of the car directly at the door, and also to reflect the light through the doorway of the car so that it may illuminate the floor of a baggage trunk placed at the doorway.

Illumination Intensities

I have heard at times some criticism of the intensities of illumination which are obtained in car lighting, with the suggestion that these should be considerably increased in line with the increase in intensities in other lines of work.

With the best installations, in coaches the illumination on the horizontal plane will be about four foot candles, and on the 45° reading plane will average about three foot candles.

In sleeping cars, with the present arrangement of lamps, the light on the 45° reading plane will average about five foot candles.

These values are, of course, lower than those recommended at present for the lighting of offices and similar rooms. It must be considered, however, that cars, with the exception of the baggage car, postal car and kitchen of dining or business cars, are not used to any extent for work. The illumination is used principally for reading for short spaces of time. In view of this fact, these intensities of illumination seem to be adequate. The intensity obtained in Pullman cars at present is certainly sufficient for any use to which it is put.

In the case of postal cars, the horizontal illumination obtained with the new installation is about six foot candles, although the specifications based on actual tests and study of the problem, allow for a considerably less intensity than this.

As I have already said, the amount of energy available for use on the car is limited—therefore, the illumination provided must of necessity be as low as possible and still be adequate. The illumination obtained, however, from the best practice at the present time appears to be quite adequate.

The Electrical Engineer as an Executive

By Alfred C. Turtle

THE chief electrical engineer on railway work can be a chief in many senses of the word. He may be a chief designer of electrical projects, or the inventor of "standards," often misapplied, a pacifier for the chief of the mechanical departments of rolling stock, or he may be an executive.

The last named is, of course, the ideal calling. Each railway has its different executive staffs and in these staffs it is to be noted that personality plays a tremendous role. Some of its leading men are extremely brilliant and outstanding in general intelligence, but often possessed with that peculiar psychological perversity of nature which surrounds itself with men of only ordinary and sometimes below ordinary intelligence. Sometimes the other extreme, that of an average executive surrounding himself with brilliant minds, is true. It is fortunate, however, that the law of averages has played a part in this matter and develops executive bodies on our different railways, so that a great number of these bodies form a standard of general efficiency which are a safe pattern and ideal for others to follow, and at the same time to a certain extent, act as a deterring influence on some of what would otherwise be tragic examples. Some of these bodies do realize the benefits of keeping equipment repaired to certain standards, such as wear limits on all rolling stock, and from boiler flue sheets down to the car trucks the majority of such defects as are not covered by Master Car Builder Association, Locomotive Association or Boiler Maker Rules.

It is only by such constancy and quality of repair and

replacement work that dependency on the movement of our vast freights can be counted upon, that interchange of equipment is handled and that service is assured in rain, snow or blizzards.

The most important feature having to do with the executive staff is the economical aspect. This part is, of course, the governing feature but it is not often given the attention which it deserves by the lower executives. While a successful (financially) railway is more prone to be generous towards one's financial needs, than a railway otherwise successful, it does not follow that the individual in general, studies the actual economics of that body from the same comprehensive point of view. More often his study of this matter is purely a personal one.

In short, he does not consider depreciation, obsolescence, interest charges, taxes, insurance, and a host of similar charges, nor does he always take care to separate his overhead charges or analyze the meaning of these as applied to his particular department. In fact, he sometimes does not know the wages and material cost of repairs required to certain apparatus, and therefore judges his charges oftentimes on such costs in extremely biased fashion.

It is therefore easily perceived from the above observations that the executive head, or chief electrical engineer, to be the ideal man in charge should be able to analyze the true financial standing of his system of repairing and replacing apparatus of designs for new systems, apparatus, etc., and also to inculcate that same attitude in those executives who carry out his orders or supply him with the necessary designs, figures on new work and general costs of the maintenance of his electrical apparatus.

The inculcating of his assistants is perhaps the hardest part and naturally calls for much personal and painstaking examination of ideas advanced. It also calls for considerable imagination, looking ahead five and ten years at a time, and also a broad understanding. With these qualities the success of an electrical department and its existence as a complete unit in itself can be safely trusted to provide a maximum of service in the largest of railway organizations.

With the smaller railways, the chief electrical engineer may not be in a position where he can have the service of assistant electrical engineers. He may be confined to the services of a draughtsman and clerk, the duties of designs, supervision of his foremen and construction gangs, and diplomatic handling of matters relative to electrical matters on the system may rest wholly on his shoulders.

A man of suitable temperament can safely handle these matters and by application can cover much ground, where considerable work is involved. His attention would of course be more general than minute in a case of the former and vice-versa where the work was of considerable less volume.

The faculty of being able to go into detail in places unexpectedly of course would tend to keep his supervisory forces on tiptoe in their ambition to keep things going in a satisfactory and efficient manner.

Where the above conditions exist and where all electrical apparatus, maintenance, construction, policy and design come directly and indirectly under the supervision of a distinct electrical staff, there is no doubt whatever as to the general overall efficiency that can be obtained.

A system such as outlined makes for better efficiency, satisfaction and standardization of methods in agreement with the Underwriters and National Safety Standards. It has a far reaching effect on the members of the department in more ways than one. For example in the ordinary run of shop breakdowns, etc., does it not generally follow that undeserved criticism is made on such occurrences? Is it not an extremely awkward situation to try to explain the cause of a specific breakdown to an irate general foreman of the shops in which the breakdown occurred, and also is it not often impossible to explain to the works manager, locomotive shop superintendent, or car shop superintendent, because of the fact that the majority of such troubles require the use of technical language to explain them which merely causes suspicion, or doubt, and confusion in the minds of these men.

If, on the other hand, the feeling of over-confidence is born in these minds through contact with the electrical man in charge and they are ready to stand by his statements with the feeling that "what he says goes," does not such a condition in turn produce a state of things intensely unsatisfactory at times? Is it not much better to be able to explain these troubles to officials who have sufficient electrical training to understand them? Such men can point out better methods of meeting such breakdown, or take steps to make a change which will almost permanently cure that particular trouble, or if the trouble was properly taken care of, can back up the man in charge and give him that sometimes needed feeling of confidence to attack and dispose of these ever-increasing troubles with fresh vigor and life.

It is infinitely better all round to attack any trouble whether it be a serious wreck on the line or the breakdown of an electric power cable or machine in the shop, with a clear and rapid working mind in condition to decide clearly, quickly and efficiently than to harass that said mind with amateur suggestions, undue condemnations and unfair criticisms.

Management under the different executives varies remarkably, but a true analysis can only be taken over a reasonable period of time, in the quality and durability of the repairs, in the steps taken to reduce the number of breakdowns and consequent repairs, in the general morale of the staffs or departments. The reduction of costs of handling in the installation of new and improved ideas and the gradual elimination of unnecessary horsework on the part of human beings, also enter into such an analysis.

A comprehensive grasp of these things by the higher executives of the electrical department and incidentally all departments of any railroad would do much to improve conditions generally. It would stave off that criticism which is so destructive to the morale of what would otherwise be good and loyal workers and would produce that constructive and reasonable criticism which we all need and in turn produce that condition of open and generous mindedness that the world is in need of today.

Criticism of the right kind will work wonders and will be welcomed by the majority of employees. "To avoid criticism—do nothing, say nothing, be nothing," is very true, but for the man who produces results although realizing that he is very often the target for unjust criticism, real constructive criticism and a little praise once in a while will surely be appreciated.

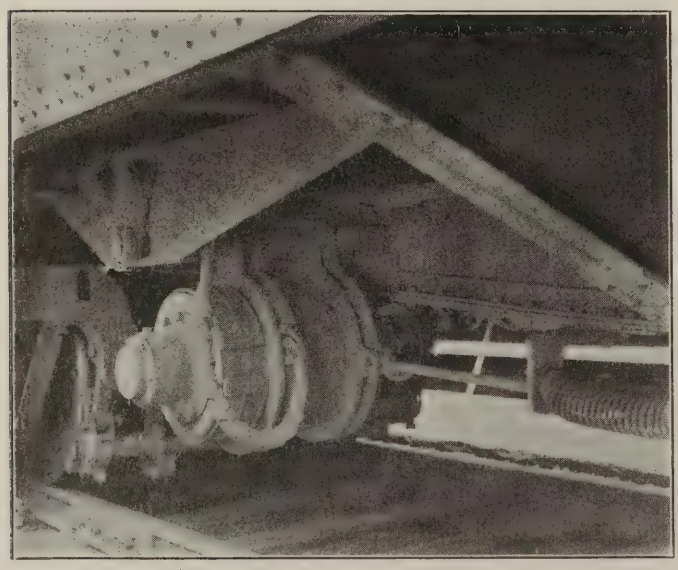
Denmark has officially licensed 3,109 private radio receiving sets. School pupils rank first with 473;; commerce, shipping and industry second with 448; office and store employees have 354; artisans, 341, etc.

THE INTERCHANGE

A Body Hung Generator That Will Not Get Out of Line

The suspension of the body-hung generator shown in the illustration is so designed that the generator will maintain its alignment after it has once been set and the suspension bearings will not bind when they are allowed to go without oil.

The machine shown is a 2.6 kw., type D, safety generator used for diner service. It was originally a truck-mounted machine and was converted to body-hung. This was done by shrinking two cast-iron rings as shown around the frame of the generator. The two rings each have a supporting lug at the top and the supporting shaft passes through holes in the lugs. The car girder supports one end of the shaft and the other end is supported from a piece of channel iron as shown. The shaft extends through a slotted hole in the channel and is supported from a piece



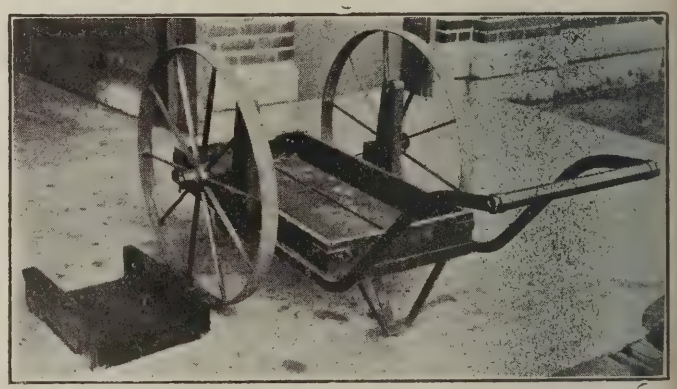
Rugged Construction and Wide Supports Keep This Generator From Getting Out of Line

of plate metal shaped like an inverted U which rests on the top of the channel. The plate is secured to the channel by means of bolts, in any desired position permitted by the slotted hole, and the generator is aligned by this means. The supporting shaft is 3 inches in diameter and can be made from a car axle.

The suspension has two points in particular to recommend it. First, the supporting rings, lugs and shaft are heavy, the rings are 13½ inches apart, which reduces the twisting action caused by the belt to a small amount and the generator cannot be pulled out of line by the twisting or warping of the suspension. Second, the supporting shaft bearings are made slightly larger than the shaft and for this reason a formation of rust in the bearing will not cause the shaft to stick or bind in the bearing. No oil is used on these bearings and although there is a certain amount of wear, this wear is so slight and the diameter of the shaft is so great that the shaft will not cut down into the bearing and seize. The support shaft is 36 inches long and supported at one end by girder and on the other by channel iron. The twist is negligible and the generator can not get out of line.

Soo Line Yard Service Cart

Distilled water and armatures are the two things which most frequently have to be moved from the shop to a car in the yard or from the car to the shop. The cart shown in the illustration was built by the electricians in the Soo



Cart Used for Carrying Distilled Water and Generator Armatures

Line Shops at Minneapolis, Minn., and is fitted with a special device for carrying generator armatures.

The body of the cart is underslung so that the cart will not tip over easily and the wheels are large so that it can be hauled over tracks without any great difficulty. The body is made of wood reinforced with iron angles bolted to the wood.

Distilled water is carried in a carboy and the carboy case or crate is fitted with two lugs bolted to opposite sides of the case. These lugs fit into the notches in the two upright pieces on each side of the cart. This arrangement prevents the carboy from sliding around in the cart, mini-

mizes shock and makes it easy to tilt the carboy for pouring.

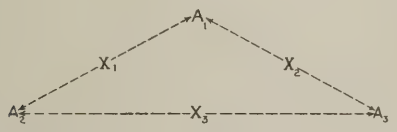
The device shown at the left of the cart is lined with a piece of car carpet and is designed for carrying generator armatures. It is placed in the cart and it is of such a width that the armature will fit snugly between the two sides. This keeps the armature from rolling around in the cart and prevents damage to coils or commutator.

Resistance of a Ground

Not infrequently the desire arises to know whether or not a ground connection is actually grounded. Without means of measuring it is impossible to determine the resistance in ohms of a ground connection, but if a Wheatstone bridge is available the desired result may be obtained by the following calculation:

Let A_1 represent existing ground rod

Let A_2 and A_3 represent other ground rods used for



Connection for Testing Resistance of Ground

making the test. They may be iron rods or pipes driven in temporarily.

X_1 is a reading in ohms between A_1 and A_2

X_2 is a reading in ohms between A_1 and A_3

X_3 is a reading in ohms between A_2 and A_3

It is evident that X_1 is the sum of the resistance of A_1 and A_2 to ground.

Then
$$X_1 = A_1 + A_2$$
$$X_2 = A_1 + A_3$$
$$X_3 = A_2 + A_3$$

It is also evident that the resistance of A_1 is equal to the reading $X_1 - A_2$

Then
$$A_2 = X_1 - A_1$$
$$A_3 = X_2 - A_1$$

Taking the equation $X_3 = A_2 + A_3$ and substituting the values of A_2 and A_3 as shown above, we have

$$X_3 = (X_1 - A_1) + (X_2 - A_1)$$

Then
$$X_3 = X_1 + X_2 - 2A_1$$

Transferring,
$$2A_1 = X_1 + X_2 - X_3$$

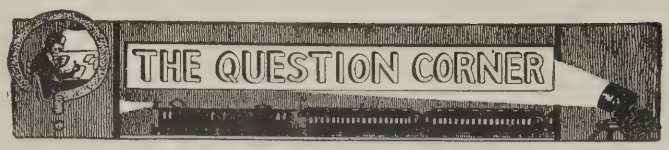
And
$$A_1 = \frac{X_1 + X_2 - X_3}{2}$$

A Few Practical Recipes

For stopping joints, etc., a good cement is one made of white lead in oil, mixed with enough white sand to make a stiff paste. This grows hard by exposure, and resists heat, cold and water.

Blue print paper can be made by coating white paper with the following solution. One pint citrate of iron ammonia; two pints red prussiate of potash; one pint gum arabic and three pints of water.

Soldering iron or steel is usually rather difficult unless the proper kind of flux is used for this material. A flux made of ten parts borax and one part sal ammoniac is probably the best to use for this work.



Answers to Questions

1. *Why do the inside or back cells of two compartment train lighting batteries become pitted and leaky more than the front cells?*

2. *What would cause the negative plates of a lead storage battery to turn red or a reddish brown?*

3. *Why is it that a battery once overheated and overdischarged cannot be brought up to full capacity until the plates are taken out, washed and recharged with new acid?*

Causes of Battery Troubles

1. The reason that the back cells of a battery become pitted and leaky more than front cells is probably due to the fact that the back cells are usually filled too full when the battery is flushed because it is difficult to see when the electrolyte has been brought up to the proper level. When this has been done some of the electrolyte slops over and the wooden tray on that end becomes soaked and slight grounds on the tank are produced. These grounds soon eat holes in the lead lining of the tank.

To remedy this trouble some device should be used which will indicate the height of the electrolyte while the cells are being flushed. Such an arrangement might be constructed using a lamp or a bell in a circuit which would give an alarm signal when sufficient water had been added.

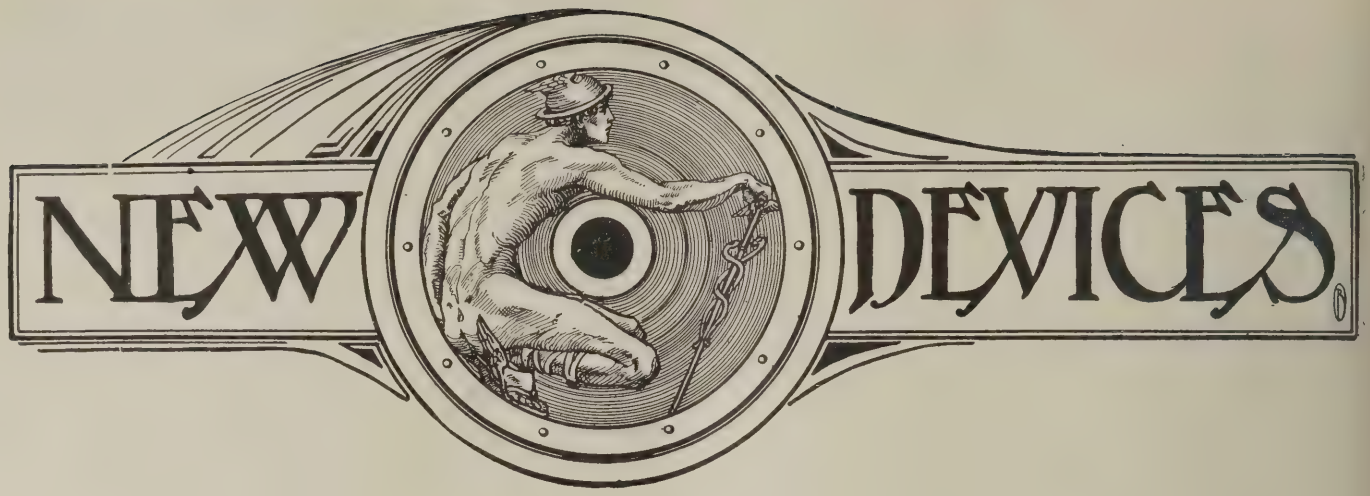
2. Under proper operating conditions the negative plate when fully charged is slate color, whereas the active material of the positive lead plate is lead peroxide which is a chocolate brown color. If the negatives become a reddish brown it would indicate that that particular cell had become reversed. This may be caused by local action due to impurities or short circuit between plates which would discharge that cell. Then when the lighting discharge current of the cells in series with it flows through this cell this current will act as a charging current in the wrong direction for this particular cell and reverse its polarity, making the negative plates lead peroxide, and the positive plates spongy lead.

3. Overheating and overcharging tend to sulphate the plates but a regular treatment of charging to remove sulphation should be sufficient. The mere fact that the battery has been overheated does not affect the acid other than making it slightly weaker because some of the sulphate of the acid has gone into the plates and accordingly it should not be necessary to renew the acid unless there are actually some impurities contaminating it.

Questions for February

1. *In an axle lighting equipment, why is it that, when a dynamo is out of level compared to the car axle to which the axle pulley is attached, that when the car is moving in one direction the belt will run to one side of the dynamo pulley, but when the car is moving in the opposite direction the belt will run to the other side of the dynamo pulley?*

2. *I would like to have you explain also why it is that when a pulley is crowned, the belt will stay in the center of the pulley running to the high point, but when the shaft of the dynamo is not parallel with the car axle, the belt will run to the low side, or the side nearest the car axle.*

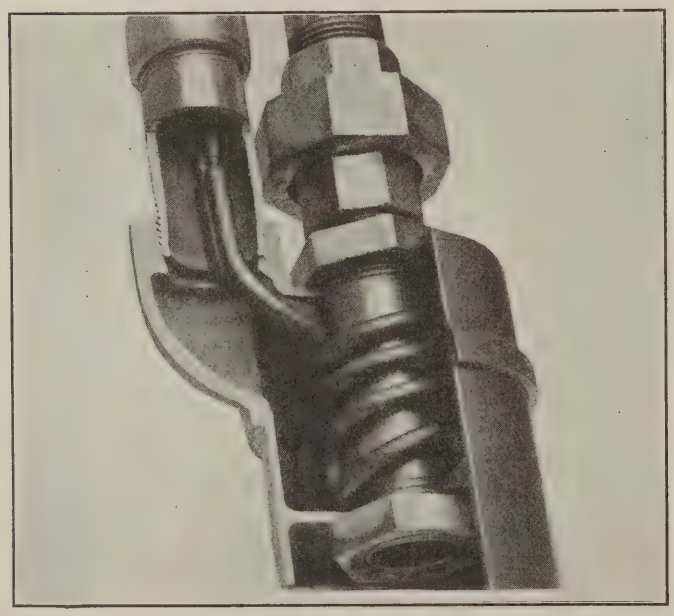


Electric Sand Pipe Heater

A device known as the Universal Electric Sand Pipe Heater, designed to keep sand pipes on locomotives, street cars and so forth from clogging at the lower end, has been developed by the Universal Electric Sand Pipe Heater Company, 1536 Commercial Trust Building, Philadelphia, Pa.

In stormy weather, the lower end of the sand pipe is always wet and it is a well-known fact that dry sand will not flow from a wet pipe without part of the sand sticking to the side of the pipe, eventually closing the outlet. The function of the device is to keep the orifice dry, permit a flow of sand at all times and thereby insure full tractive effort and maximum adhesion for braking when needed.

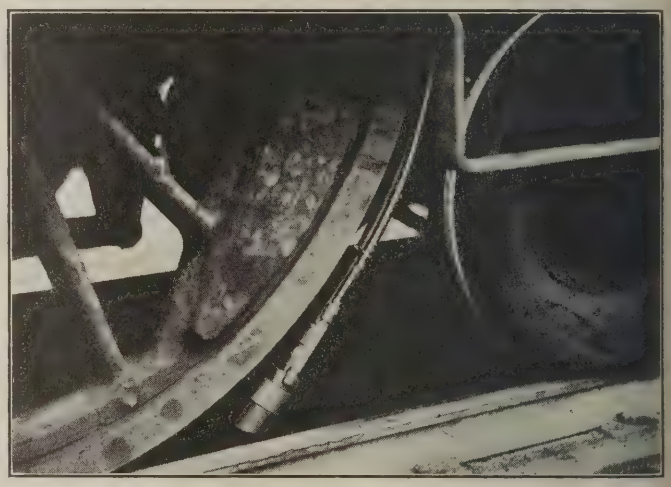
The heater is a simple device which is screwed on to



Heater with Section Cut Away and Lagging Removed to Show Construction

the lower end of the sand pipe and in effect is a shell which surrounds the pipe. Inside of the shell and touching the sand pipe is an electric heating unit connected to the headlight generator. The space between the heating unit and the outer shell is filled with asbestos lagging. Two sizes of heaters are manufactured using 64 and 80 watts respectively and there are two units used on a locomotive.

Laboratory tests on the device were made by a large eastern railroad about a year ago. Pipes were set up as on a locomotive with sand box and valves for sanding track. Water was allowed to trickle down the pipe and a blast of air equivalent to a cross wind blowing at 30



Electric Sand Pipe Heater Applied to Locomotive

miles an hour was projected against the end of the sand pipe. Sand was allowed to flow down the pipe every 10 seconds. Without the heater this treatment closed the end of the pipe with a grouty sander in from 5 to 15 minutes. With the heater turned on there was no wet sand in the lower end of the sand pipe at the end of an hour and fifteen minutes.

At a later date a road test was made. A five-gallon can of water was placed on the running board of a locomotive and a hose extending down to a point near the lower end of the sand pipe, was used to trickle water onto the pipe. In making a 50 mile run without the current turned on, the pipe clogged up five times, being cleaned out each time. On the return trip, the current was turned on and the pipe gathered no wet sand.

Another test was made in the freezing room of the Penn Cress Ice Cream Company at Cresson, Pa. The sander was operated at a temperature of zero, with water trickling on the sand pipe. This was continued for two hours, at the end of which period there was nothing in the pipe.

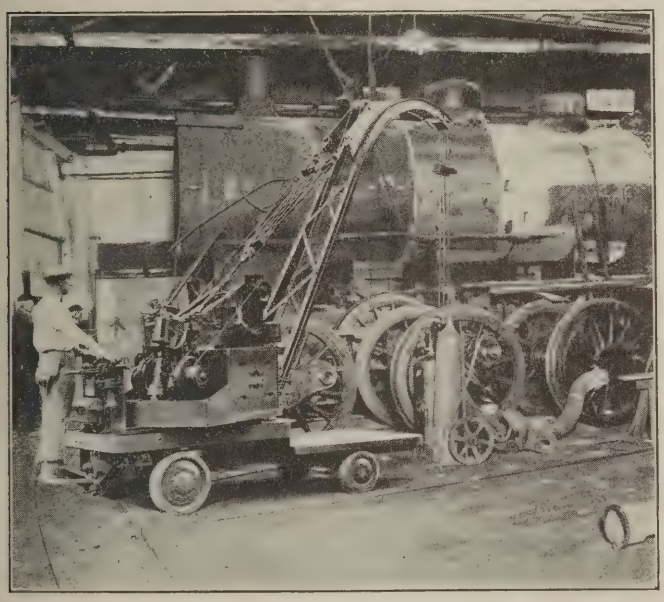
In regular use on road locomotives, the device has been used to keep the sand pipes clear under a variety of conditions of bad weather, including low temperature, rain and snow.

Crane for Enginehouses

The locomotive type crane made by the Baker R & L Company, Cleveland, Ohio, has been completely redesigned for railroad use. The new crane, shown in the illustration, has a wide field of usefulness not only in enginehouses but in all railroad departments where heavy material must be handled without the aid of overhead traveling cranes. With an 8-ft. boom and 60-in. wheelbase the new crane may also be operated inside a standard box car and thus greatly reduce the number of laborers required for loading and unloading these cars.

For enginehouse use the new Baker crane can be provided with a standard 12-ft. or longer boom up to 19 ft. With the latter length a lift of 192 in. can be obtained at a 95-in. radius and the crane is therefore suitable for reaching over the tops of locomotives and removing front doors, dome casings or covers, dry pipes, air compressors, or other parts high up on the locomotive which ordinarily require the effort of several men and more or less laborious work to remove or apply.

A short, auxiliary boom can be furnished when desired for working underneath the running boards, greatly facilitating the removal of heavy rods, crossheads, pistons, etc., which on modern locomotives have far outgrown the point where they can be readily put up by hand. When not in use this auxiliary boom can be folded up.



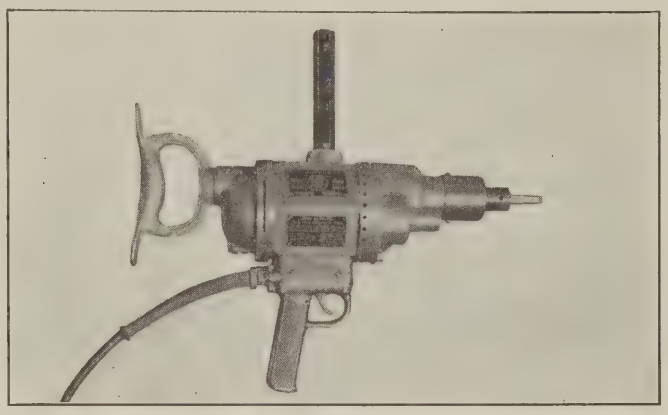
A Baker Locomotive Type Crane Speeds Heavy Repair Work in an Enginehouse

The special feature of this crane is that all of its movements are electrically driven with one motor for propelling the truck, a second for swiveling the crane and a third which drives the main hoist. The main hoist consists of two drums, one for lifting the hook and the other for racking the boom. Power is applied to either of these drums by means of magnetically-operated clutches.

The rated capacity of the crane is 3,000 lb. at a 7-ft. radius, the hoisting speed at that load being 7 ft. per min. and the traveling speed 265 ft. per min.

Electric Screw Driver and Socket Wrench

The Black & Decker Manufacturing Company, Towson Heights, Baltimore, Md., has added to its line of electric tools a portable electric screw driver and socket wrench for heavy-duty production work. The tool weighs fifteen pounds, and is designed for driving large wood screws, lag screws and running up nuts on large bolts.



Motor Driven Wrench and Screw Driver

The spindle is equipped with a positive clutch which automatically disengages when the forward pressure on the tool is released. The tool is equipped with a pistol grip and trigger switch, and a universal motor furnishes the power.

Multiple Operator Welder With Single Operator Characteristics

For the specific interest of our readers we give below details of two very important designs recently patented in England, which should prove of special interest to Railroad Electrical Engineers.

An electric arc welding outfit patented in England, has been developed which is designed for the use of more than one operator, at the same time keeping the characteristic efficiency of a single operator set. As is well-known, a higher voltage is necessary to start an arc than is required to keep it running and, as the drooping characteristic generator cannot be used for more than one operator, a novel method to overcome the difficulty of getting rid of excess voltage without wasting energy has been introduced in the construction of this machine.

The welding generator supplies current at from 30 to 40 volts, and thus has a sufficiently high voltage to enable it to be used for all regular welding operations. Connected in series with this generator is a small booster which generates current at about 35 volts; the voltage available for striking the arc therefore being between 65 and 75 volts. Immediately the welder starts the arc with his electrode, a contactor device withdraws the booster and welding proceeds, on the main generator.

The most *important* features of this plant are, economy in running cost, flexibility and ease of adjustment, and absence of large and wasteful resistance.

The special contactor gear with which this plant is fitted is highly ingenious, and in the design of this apparatus very careful consideration has been given to all vital points necessary in the construction of an electrical arc welding outfit. The apparatus has been introduced and patented by the Premier Arc Welding Co., Ltd., of Abbey Wood, England.

General News Section

The Bridgeport Brass Company announces the removal of its Philadelphia office from the North American Building to Room No. 532 of the Bankers Trust Company.

The Okonite Company, Passaic, N. J., has recently opened a branch office in Pittsburgh, Pa., at 1111 First National Bank Building. Edward A. Damrau, district manager, is in charge.

The General Railway Signal Company has moved its New York City office from the Canadian Pacific building, 342 Madison avenue, to the Pershing Square building, 100 East Forty-second street.

The Ohio Brass Company, Mansfield, Ohio, recently bought about five acres of land and some buildings on a triangular plot just across the Pennsylvania railroad tracks from its present Mansfield plant.

The Schweyer Electric & Manufacturing Company, Easton, Pa., proprietor of the Schweyer induction automatic train control, has brought suit in the Federal Court at New York City against the Regan Safety Devices Company alleging infringement of patents.

The Canadian National has opened a radio broadcasting station at Calgary, Alt., from which musical and other programs will be broadcast. Receiving sets are now in operation on the trans-continental trains of the National lines and it is the intention of the company to install similar sets in its hotels.

A southbound express train of the Pennsylvania Railroad was derailed at St. George, 22 miles south of Franklin, Pa., on January 30 and the engineman, fireman and a porter were killed. The locomotive fell down a bank and a sleeping car was overturned; and 11 passengers were injured, most of them not seriously.

The petition of the Buffalo, Rochester & Pittsburgh for a modification of the Interstate Commerce Commission's automatic train control order to permit of an installation on the Rochester division between Rochester and Ashford, N. Y., instead of between the points designated in the order, has been denied by the commission.

J. L. Marsh is now associated with Louis W. Sipley at 206 Fuller Building, Philadelphia. They are representing The Crescent Truck Company, manufacturers of storage battery trucks and tractors. They have both been engaged in railway sales for a number of years and Mr. Marsh has resigned from the Safety Car Heating and Lighting Company with whom he has been associated for the past 15 years.

The orders received by the General Electric Company for the year ending December 31, 1923, amounted to $304,199,746, compared to a total of $242,739,527 for the year 1922, or a gain of 25 per cent, according to a recent announcement by Gerard Swope, president of that concern. For the fourth quarter of 1923, orders totalled $74,452,442, as compared with a total of $66,568,333 for the corresponding quarter in the year 1922, or a gain of 12 per cent.

The first of a new type gasoline-electric passenger car for use in steam railroad service has been sold to the Chicago Great Western Railroad and will be demonstrated some time in May or June. This car was developed by the co-operation of the General Electric Company with the St. Louis Car Company, the Electromotive Engineering Company of Cleveland and the Winton Engine Company. It will seat 56 persons, has 100 square feet of baggage room, is arranged for double-end operation and will be capable of a maximum speed of 60 miles per hour. The car will weigh, complete and "ready to roll," approximately 54,000 lb. It will have enough capacity to handle a 35-ton trail car behind it.

The Pawling & Harnischfeger Company, Milwaukee, Wis., manufacturers of excavators, cranes and machine tools, have recently opened new offices in the South. N. B. Norris, formerly district manager at New Orleans, is now district manager of the Memphis, Tennessee office. D. J. Murphy, formerly at the New Orleans office, is now district manager of the Texas district with headquarters at Dallas, Texas. F. W. Truex will continue as district manager at Atlanta, Georgia, with offices at 212 Haas Howell Bldg. W. J. Dugan, as southern sales manager, will assume charge of the entire southern territory with headquarters at Memphis. For convenience, a complete stock of excavator renewal parts will be maintained at the Memphis office.

United States Civil Service Examination

The United States Civil Service Commission announces the following open competitive examination: radio engineer, $4,000 to $5,000 a year; associate radio engineer, $3,000 to $4,000 a year; assistant radio engineer, $2,000 to $3,000 a year.

Receipt of applications will close March 11. The examinations are to fill vacancies in the Signal Service, McCook Field, Dayton, Ohio and Camp Alfred Vail, N. J., at an entrance salary of $2,000 a year, plus the increase of $20 a month, and vacancies in the Federal classified service throughout the United States at the salaries indicated above.

The duties of appointees are to conduct or superintend the development, design, construction, installation, standardization, and the writings of specifications for practical and special apparatus and methods of radio communication, such apparatus to include sets for land use for more or less permanent stations, also for portable land stations, and for airplane and ship sets; to carry out advanced technical work in radio research; to analyze the data accruing from observations of the operation of various radio apparatus

and installations; to make recommendations as to policy, apparatus, or installation in accordance with inspections; to plan and execute experimental investigations; and to perform other related work.

Competitors will not be required to report for examination at any place, but will be rated on their education, experience, and fitness, and publications, reports, or thesis to be filed with the application.

Full information and application blanks may be obtained from the United States Civil Service Commission, Washington, D. C., or the secretary of the board of U. S. civil-service examiners at the post office or customhouse in any city.

Cost of N. Y. C. Electrification and Grade Crossing Elimination in New York

The Transit Commission of New York has analyzed the cost of the proposed rebuilding of the freight line of the New York Central on the west side of Manhattan Island and places the total at $97,000,000 in all. The cost of the work is broadly divided as follows:

Electrification	$17,000,000
Changes not involving electrification nor elimination of crossings	35,000,000
Elimination of grade crossings	45,000,000

In the case of the last item the cost would be divided as follows:

(a) Railroad, 50%	$22,500,000
(b) City, 25%	11,250,000
(c) State, 25%	11,250,000

There is, however, in this item a charge of about $5,000,000 for additional land for new right of way which may be questioned by the Transit Commission. If the Transit Commission's contention is correct the result would be that the railroad's charge for elimination of grade crossings would be increased by $2,500,000 and the state and city's charge therefore would be decreased each by $1,250,000.

Assuming that the charge for land is divided between the railroad, the state and the city, the total estimate of $97,000,000 would be divided as follows:

State		$11,250,000
City		11,250,000
Railroad—		
Electrification	$17,000,000	
Other changes	35,000,000	
Elimination of grade crossings	22,500,000	
		74,500,000
Total		$97,000,000

Assuming that the charge for land remains wholly on the railroad, the division of cost would be as follows:

City		$10,000,000
State		10,000,000
Railroad—		
Electrification	$17,000,000	
Other changes	40,000,000	
Elimination of grade crossings	20,000,000	
		77,000,000
Total		$97,000,000

These figures are based on data presented by the railroad company which have been examined by the Transit Commission at its hearings on the subject and by its engineers in private studies.

Route Selected for Trans-Sahara Railway

The French Ministry of Public Works has planned a tentative route for the proposed Trans-Sahara Railway. This line the French government proposes to build in order to bring its provinces south of the desert into direct communication with the Mediterranean and thus with France. The line will begin at an inland place called Wagadugu in French West Africa and extend northward across the desert to the Mediterranean port called Oran in Algeria. A short section of the line outside of Oran has already been constructed, but the route still to be built is over 2,000 miles in length. It is planned to operate the line by electricity. It is understood that the Paris, Lyons & Mediterranean Railway will operate the property on behalf of the Government. The main interest in this line is strategic, since it will give direct communication with important colonies without exposing ships to dangers which might await them in the Atlantic Ocean in time of war.

The "Searchlight Special" on the P. R. R.

The lineman, of the telegraph department, is one of the few men in outdoor railroad service who is not liable to be called on for much night work—or, rather, the lineman *was* thus easily circumstanced. Today he cannot be so sure. B. F. Dickinson, supervisor of signals of the Philadelphia division of the Pennsylvania Railroad, reduced the wire troubles caused on his division in the last cold snap (when Boreas reduced the length of the wires) by going out with searchlights at 2 a. m.; and between Harrisburg and Lancaster, 36 miles, mended eight breaks in the wires.

This little enterprise for saving time was not originated on the spur of the moment. Some months ago, when wires were not suffering from low temperatures, James C. Moore, foreman, conceived the idea of using locomotive headlights to illuminate wire lines, and a couple of headlights, with strong reflectors, were fitted on the side doors of a work car, one on either side of the car; the reflectors so arranged that they could be adjusted to throw the rays up or down, forward or backward. Thus the wires could be readily followed at places where the pole line goes over a hill. The lights may be fed from standard passenger car lighting systems, either 32 volt or 65 volt. An experimental trip was made one night last autumn.

On the advent of zero weather and broken wires, the car, with its lights, was made ready; and a train of three cars was started out, all of the lights in the cars being extinguished except the searchlights. The watchers for the breaks placed themselves in position far enough back from the searchlights to get good views of the pole line on either side of the road. On discovery of a break, the engineman was signaled to stop and but little time was consumed in setting the train back to the break.

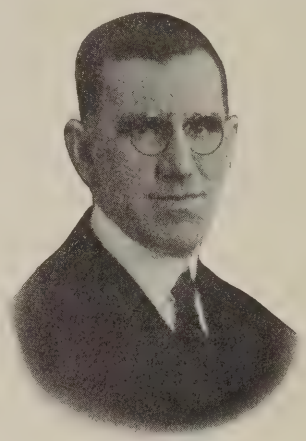
Personals

A. H. Darker, chief electrical engineer of J. Stone & Co., Ltd., Deptford, London, S. E., sailed from England on Friday, January 18, for an extended business trip around the world returning home via Canada and the United States.

C. P. Taylor, whose appointment as electrical engineer of the Norfolk & Western with headquarters at Roanoke, Va., was announced in the *Railway Electrical Engineer* of January, page 33, was born on October 12, 1886, at Ironton, Ohio, and completed an electrical course of the International Correspondence School, Scranton, Pa.

He entered railway service on May 1, 1904, as an electrician with the Norfolk & Western at Roanoke, Va. In September, 1906, he was appointed electrical foreman at Portsmouth, Ohio, and on December 1, 1909, was transferred to Bluefield, W. Va. He was later transferred to Roanoke and Norfolk, Va., in the same capacity and in February, 1917, was promoted to assistant superintendent of terminals at Norfolk, Va., which position he was holding at the time of his promotion.

Charles W. T. Stuart has resigned as foreman of car lighting, Pennsylvania Railroad, to accept the position of representative with the Philadelphia office of the Safety Car Heating & Lighting Company.



Chas. W. T. Stuart

Mr. Stuart was born in Philadelphia in 1888 and after studying at the Engineering School of the Drexel Institute, he entered the car lighting department of the Pennsylvania Railroad in 1909. At that time there were but few electric lighted cars. Mr. Stuart has made a specialty of this particular branch of railway equipment ever since be became connected with the railroad.

He has contributed largely to railway publications on car lighting subjects, including a series of articles in the *Railway Electrical Engineer* on the fundamental principles of car lighting. His largest contribution to car lighting literature is his recent book "Car Lighting by Electricity," which is the first complete volume covering this important subject.

Leroy W. Allen has been appointed sales engineer of the New York office of the Hazard Manufacturing Company and will make his headquarters with that office at 533 Canal street after February 1, 1924. Mr. Allen entered the employ of the company in 1903 and has since been connected with the sales organization in New York, Chicago and Wilkes-Barre.

Daniel J. Morgan, for several years sales agent of the insulated wire department of the Hazard Manufacturing Co., has been appointed sales engineer with the general offices at Wilkes-Barre, Pa., effective February 1, 1924. Mr. Morgan entered the employ of the company in 1900 and held various positions with the manufacturing departments and sales office until 1917 when he was appointed sales agent which position he has held until his recent appointment.

Herman W. Schroeder has been appointed district auditor of the southwestern district of the General Electric Company, following the recent creation of this district. Mr. Schroeder was first employed as a bookkeeper in the Southwest General Electric Company in 1911. In 1920 he became auditor of that concern. Under the new arrangement he will have charge of accounting, credits and collections in the General Electric southwestern district, as distinguished from the Southwest General Electric Company, distributing jobber, as it has been heretofore known.

Alexander McIver has been appointed supervisor of heavy traction development of the Westinghouse Electric & Manufacturing Company. Mr. McIver is a graduate of the University of North Carolina and he also took the electrical engineering course at Johns Hopkins University, which he completed in 1895. He was first associated with the Sprague Electric Company where he assisted in the earliest work on the Sprague multiple unit control and the later installation of this system on the South Side Elevated Railroad, the Brooklyn Rapid Transit and the Boston Elevated Railroad. Later Mr. McIver was connected with the Chicago & Milwaukee Electric Railway as master mechanic. From this position he transferred to that of superintendent of equipment of the New York City Railways—the consolidated surface lines of New York City. Mr. McIver joined the Westinghouse forces in December, 1909. The electrification of the New York terminal was then under way and he supervised the execution of Westinghouse contracts for this work. While making his headquarters in New York he supervised Westinghouse activities on the Long Island Railroad and the rapid transit and surface railroads in New York City as well. Upon the undertaking of the contract for equipment of the Norfolk & Western electrification, he was appointed resident engineer in charge for the Westinghouse Company and on the completion of this work he was appointed to a similar position on the Chicago, Milwaukee & St. Paul electrification, where he had charge of development by the Westinghouse Company. Mr. McIver will make his headquarters at the East Pittsburgh, Pa., works of the Westinghouse Company.

Crawford McGinnis has been appointed vice-president of the Pyle-National Company, Chicago; L. H. Vilas has been appointed assistant general manager and George E. Haas has been appointed special representative. Crawford McGinnis was born in Oakland City, Ind., in 1880. He received a common school education in the western states and served his apprenticeship as a machinist on the St. Louis-San Francisco. He followed railroad work, with the exception of a short time at sea, specializing in the air brake. His earlier experiences were in Mexico and Central America. Mr. McGinnis left the service of the Minneapolis, St. Paul & Sault Ste. Marie in 1912, to represent the Pyle-National Company. Lawrence H. Vilas was born in New York City in 1895. He received his education at St. Paul's School, Concord, N. H., and shortly after leaving school he enlisted in the New York National Guard and served overseas in France in the World War. After the close of the war he took up with the Pyle-National Company. George E. Haas was born at Wadsworth, Nev., in 1883, and was educated in the schools of California and Minnesota. After serving a two-year apprenticeship with the Milwaukee Electric Company, he completed a full machinist's apprenticeship in the shops of the Chicago, Milwaukee & St. Paul, at Milwaukee. He is familiar with railroad development, having specialized in air brakes and electric equipment.

Railway Electrical Engineer

Volume 15 MARCH, 1924 No. 3

Indexes for 1923

The index for volume 14 of the *Railway Electrical Engineer* has been completed and copies are ready for distribution. There has been some delay this year in getting out the index but copies may now be had by those of our subscribers who desire them. Requests should be addressed to the Circulation Department, *Railway Electrical Engineer,* 30 Church street, New York City.

Progress in Electrification

New applications of electric traction to trunk line roads continue to be made at rather long intervals. Recent developments, however, indicate that argument and guess-work based on enthusiasm will be factors of relatively little importance in making decisions concerning future applications.

As much as thirty years ago, it was thought that electric traction would quickly find wide application on trunk line railroads. Argument had much to do with retarding this application, for along with the early development an argument was started concerning the relative merits of alternating and direct current apparatus. The railroad operator was naturally skeptical of a new tool with which he was totally unfamiliar and in many cases drew the natural conclusion that if the electrical men could not decide which system should be used, then it was a good thing to let alone.

This argument effectively retarded the development of electrification up to as late a date as 1922 and probably will have some effect in years to come. Relatively little is heard about it now, however. Most of those conversant with the subject concede merit to both systems and believe that local conditions will usually govern the choice. One kind of power for all electric traction systems would, of course, be desirable and it is to be hoped that further progress will show that this is a possibility. In view, however, of the present development of apparatus and the wide variety of conditions under which it is used, it would appear that this form of standardization would be premature if made now.

Enthusiasts have in the past been prone to resort to exaggeration in order to make electric traction appear more attractive and the result, as might be supposed, was a boomerang. These enthusiasts are now more appreciative of the development work done in the last few years toward making the steam locomotive more powerful and more efficient. In fact, there is probably more possibility of increasing the efficiency of a steam locomotive than of increasing the efficiency of an electric traction system. The possibilities for the steam locomotive seem to be limited by the complications involved, while any great improvement of electrical efficiency calls for some radical change in power development.

It is now becoming generally understood that the greatest advantages of electric traction lie in its ability to sustain high tractive effort at relative high speeds and in its ability to work more hours a day out of the 24. These characteristics make it most suitable for conditions of heavy traffic and heavy grades and the advantages gained must be weighed against the increased cost that goes with electrification.

Enginehouse Wiring

Experience in the wiring of enginehouses has taught designers a lot of "don'ts." The problem presents so many difficulties that the amount of constructive knowledge available is limited. Of course, enginehouses are wired and lighted in a manner that is accepted as satisfactory by the workers in the enginehouses, but in most cases the lighting is not up to the standard used in shops, and the wiring system deteriorates rapidly under the influence of locomotive gases.

Of late there has been a marked tendency to provide more light. Satisfactory wiring and easy maintenance are often sacrificed to this end. It makes the installation cost more and the operating and maintenance costs are increased but this added cost is almost invariably offset by the improvements made in working conditions. Improved design of enginehouses with better ventilation has helped materially, as reflectors do not have to be cleaned so frequently and corrosion of conduit is reduced. For example, in a northern climate, particularly where the enginehouse ventilation is poor, there is much condensation of steam on the conduit and there is much breathing —drawing in and exhaling of steam and gas from the conduit system—due to wide variations of temperature. In southern climates where the doors of the enginehouse can be left open eleven or twelve months in the year, the problem is less difficult. Improved heating and ventilating systems, however, are in a measure decreasing the difference between northern and southern conditions.

Recent installations show a marked tendency toward the use of overhead lights or floodlighting units with a wide beam spread. These installations have also included such features as the use of lead covered wire, conduit coated inside and out with lead, and the placing of the conduit inside the forms in building concrete enginehouses. None of these efforts have proved to be the panacea for

all ills, but they offer real advantages and are well worth trying, particularly because the wiring system is constantly becoming more complex with the addition of more lights, welding feeder circuits, power circuits, 32-volt extension circuits, etc.

Lighting commissions and a demand for improved working conditions are creating an increasing demand for improved lighting. It is to be hoped that these demands will not be so insistent as to cause the installation of lighting systems which are inefficient, short lived and expensive. There is, however, a need of improvement and the subject is one which deserves considerable attention.

Armature and Field Coil Repairs

With the constantly increasing number of electric motors and generators in railroad work, the problem of their repair becomes one of no small importance. Repairs should be made in accordance with some system of standards which has been tried out and found to be reliable. Moreover, the winding standards for railroad shops should not necessarily be the same as those for the repair of motors and generators in other lines of work. The different conditions under which the equipment must function have much to do with the kind of attention which it should receive in the repair shop. The machine that is lightly loaded and worked but a few hours a day will need different treatment from one which operates under adverse conditions, heavily loaded, and which works 24 hours a day. These factors should be taken into consideration when any standards for winding repairs are being considered and the specifications should be lived up to in regard to the methods of varnishing and baking. Some well tried methods for testing the completely repaired parts should be practiced so that it may be known that they will function in a satisfactory manner when they are put back into service.

The establishment of winding standards in railroad repair shops and the living up to these standards, once they are established, will go far towards creating a condition which will result in fewer failures and better performance.

Contribute to the Interchange

The Interchange Department of the *Railway Electrical Engineer* is a section which has been developed to interest and help electrical men who are engaged in doing practical work. An effort is made to put in this department each month some few hints or ideas which may be of help to those of our readers who are always on the alert to find the best way of accomplishing their daily tasks.

Every railroad shop has particularly good methods for doing many kinds of jobs, but unfortunately too large a proportion of them never become known outside of the shop where they originated. The reason for this is that those who developed these ideas will not take the trouble to write them up for publication. It may be you have often thought when you have looked for the Interchange Department that the number of new ideas was not as great as you would like to see. But, do you ever think seriously enough about it to take the next step and send in some pet idea of your own.

It is only by the interchange of ideas that the Interchange Section of the *Railway Electrical Engineer* can possibly be of greatest service to you and we are again taking this opportunity to urge every reader to contribute something to this department. It is only through such co-operation that the interchange can fulfill the purpose for which it was designed. The *Railway Electrical Engineer* realizes that each man's time is worth money to him and will pay for contributions of this kind which are published in its columns. Do not put off the matter longer but send in at once a description of that little stunt or device in which you take so much pride. Let your friends have the benefit of it.

Where Is the Limit?

It is only a few years ago that electricity was but a small factor in the operation of a railroad. Times have certainly changed! No longer can electric energy be disregarded and relegated to the background as a matter of little importance, for there does not exist a single department where electricity has not come to be depended upon for successful operation of some particular function. In fact, the ramifications of electricity throughout the railroad field have become so extensive that it is rapidly getting to a point where it is exceedingly difficult for one man to be thoroughly posted on all of the various applications.

At the present time, the electrical engineer is supposed to be acquainted with automatic train control, electric welding, self-propelled cars, electric locomotives and trucks and tractors. He must be informed on the general subject of illumination for all purposes in shops, engine houses, stations, offices, yards, cars and locomotives. Not only must he be especially familiar with the illumination of passenger cars from the lighting point of view but he must also be an expert in the maintenance of carlighting generator and battery equipment. He should know the whys and wherefores of power plant apparatus and be familiar with shop motors, controllers and similar accessories. And finally, among the latest additions to his already crowded list, is the application of radio to moving trains.

It is only by the greatest perseverance that any one man can hope to measure up to responsibilities indicated by such a list. As a matter of fact, it is not possible for any one man to really grasp in full detail all of the many diversified branches outlined, although it is possible for the right kind of an engineer to supervise all of these various activities. The growth in electrical applications on the railroad is rapidly extending and it is important that the electrical department be properly organized and strengthened to meet these increasing demands.

New Books

Practical Control of Electrical Energy—By Alfred George Collis, 160 pages, illustrations, diagrams, 9 in. by 7 in., bound in cloth. Published by Henry Frowde, and Hodder, Stoughton, London. Price, $3.50.

A collection of data relating to the design of measuring instruments and systems, protective apparatus, switches and other devices used for controlling electric power in everyday practice. Mathematical complexities are avoided, the data and principles being presented in simple language; and the treatment of the subject is descriptive.

Reclaiming Damaged Locomotive Headlight Sets

Baltimore and Ohio Has Unusually Complete and Effective Facilities for Turbo-Generator Repair Work

Part I

REPAIR work on headlight turbo-generator sets as done in the Cumberland shops of the Baltimore & Ohio has been developed to such a degree that it may properly be termed reclamation. The work done includes practically every part of the headlight set and in

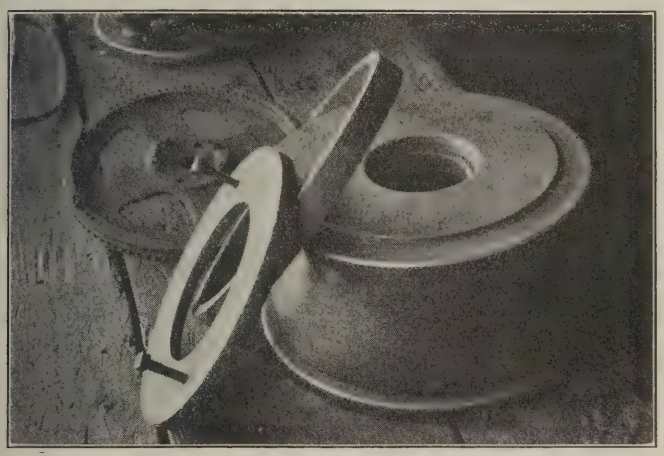


Fig. 1—Block and Rings Used for Applying Buckets and Shrouds to Turbine Wheels

arranging and laying out the work, the economies of each operation have been given careful consideration. The result is that the repair department has saved much real money for the railroad.

The shop in which the work is done is arranged so that there is a regular procedure of operations. A bench, shelf or bin is available for each of the various parts of the set as it is dismantled and for each part after it is repaired. The methods described in this article are used in the repair of Pyle-National machines.

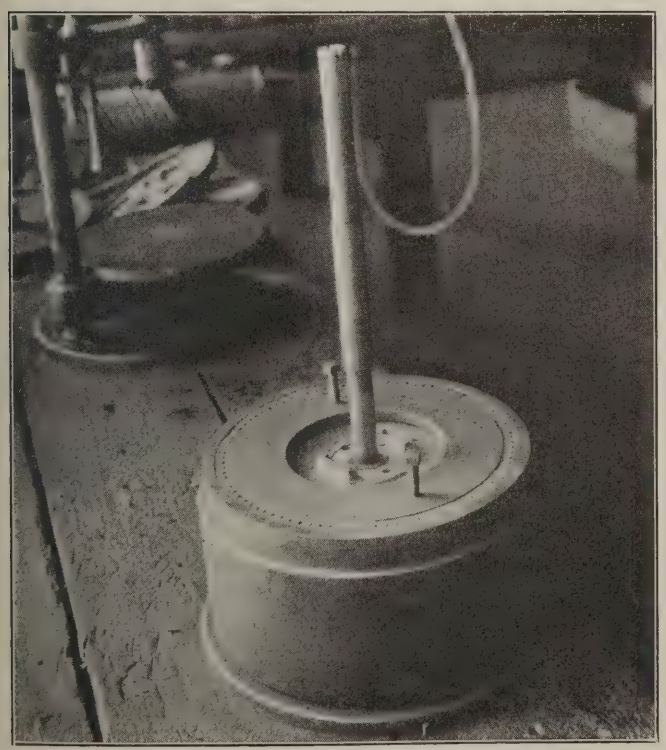


Fig. 2—Block and Rings Shown in Fig 1 with Turbine Wheel in Place

Turbine Wheels

The buckets are the most frequently damaged part of the turbine and the first operation usually consists of stripping off the damaged buckets and shrouds. The old shaft is removed and while the wheel is being repaired it is fitted with a new or reclaimed shaft taken from stock. If the wheel is warped or twisted, it is straightened with a hammer on the block or casting shown in Fig. 1.

The device shown in Fig. 1 is also used for applying new buckets and shrouds on type E-2 turbine wheels. The

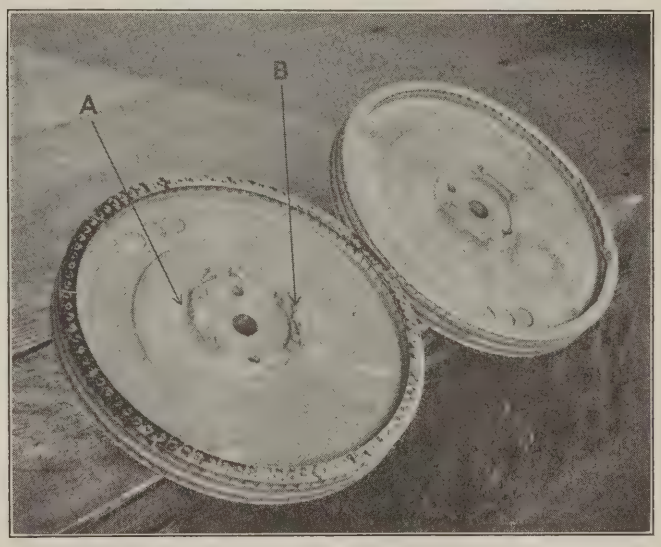


Fig. 3—A Repaired and a Damaged Turbine Wheel

large casting is 13 in. in diameter and 8 in. high. The hole in the center is 4⅜ in. in diameter and the boss at the top is ⅝ in. high and has an outside diameter of 10 7/16 in. The flat base casting under the large casting has a circular groove 10 in. in diameter cut in the top and there is a similar groove cut in the under side of the large casting. There are 18 or 20, ½-in. balls in these grooves which support the large casting and allow it to be rotated easily. The large ring shown at the left has inside and outside diameters of 11½ and 12½ in. respectively and is 1¼ in. high. The diameters of the smaller ring are 6 1/16 in. and the 10 7/16 in. and the ring is made of ½-in. material.

For repairing type K-2 turbine wheels another casting, about 2 in. thick is used which will fit on top of the large casting shown in Fig. 1. This smaller casting is provided with rings like those shown in Fig. 1, but of such sizes as will fit the K-2 wheel.

The wheel to which the buckets are to be applied is placed on top of the casting with the shaft in a vertical

position and new buckets are fitted into the holes in the inner shroud on the turbine wheel. The two rings, described previously, are fitted inside and outside of the circle of loose turbine buckets and automatically hold the buckets at the proper angle. The outer shrouds are then put in place over the outer bosses on the turbine buckets and the bosses which project through the holes in the shrouds are riveted down with a hammer and a flat punch as shown in Fig. 2. If the inner ring of the jig is then too tight to be removed easily, it can be lifted out by turning down the two cap screws shown. The buckets are applied to the other side of the wheel by turning the wheel over and repeating the operation. The inner bosses of the turbine buckets which project through the holes in these inner shrouds are upset or riveted by holding the edge of the wheel in a vise and driving a rivet set or flat ended drift down between the two inner shrouds. The operation is then completed by brazing the ends of the outer shrouds together with an oxyacetylene welding torch.

As damage to the wheel may be caused by the governor weights working loose, special provision is made to do away with this source of trouble. A damaged turbine wheel is shown at the right in Fig. 3 and a repaired wheel

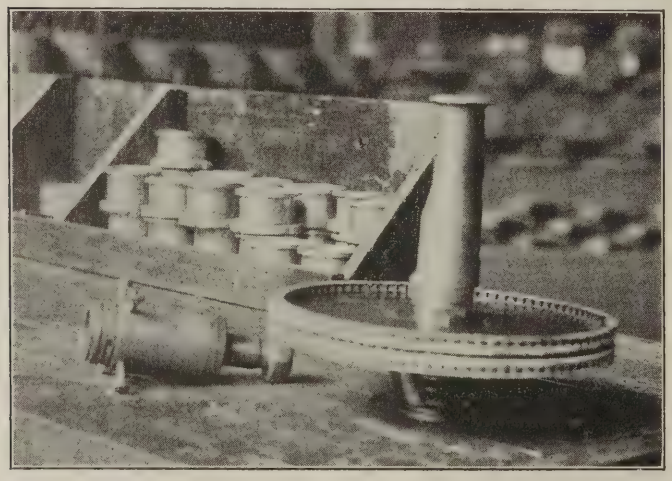


Fig. 4—Turbine Wheel with Mandrel and Puller for Applying and Removing Metallic Packing Retainer

at the left. A recessed boss on either side of the center is regularly used as a fulcrum to hold one end of the governor weights. Under certain circumstances, the governor weights may lift out of this fulcrum and this is prevented by drilling a small hole in the center of each boss or fulcrum and placing a small flat head rivet in each hole. Two of the rivets before applying are shown lying on the wheel at the left (Fig. 3) and two more are shown in place. The rivets are held in place with a tack weld applied to the outer edge of the rivet head.

The metallic packing retainer which is applied to the turbine wheel on the side away from the generator is secured by a driving fit. It is driven on by means of the mandrel shown in place on the wheel in Fig. 4. The packing retainer is removed with the puller shown at the left in Fig. 4. The puller consists essentially of a hollow cylinder, one end of which will fit over the end of the packing retainer. After it is in place it is secured to the packing retainer by the four small cap screws and the ring is pulled off by turning down the large cap screw which is threaded into the opposition end of the puller.

The apparatus shown in Fig. 5 is used for balancing the turbine wheels. After the governor has been repaired and replaced on the wheel, the wheel with governor mounted on a special shaft of known accuracy is placed on the parallel knife edges shown in the foreground and tried for balance. The balancing is accomplished by drilling small quantities of metal out of the web of the wheel at the proper point.

After balancing, bearings are applied and the bearings

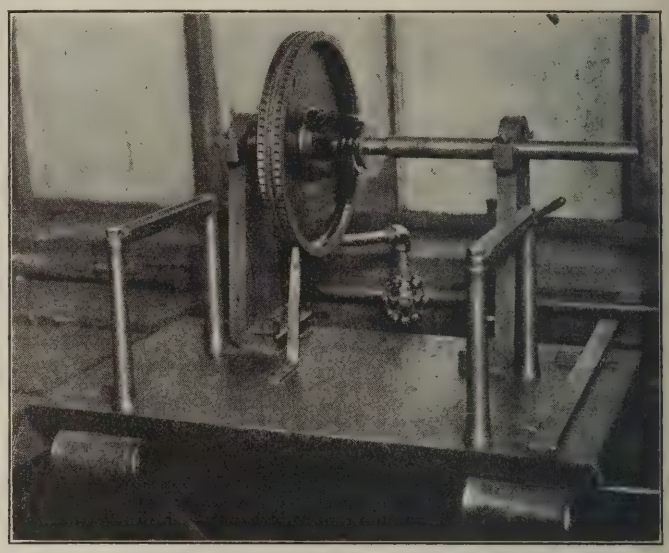


Fig. 5—Stand Used for Balancing and Truing Turbine Wheels

are secured in the bearing housings on the pedestals shown at the back in Fig. 5. The housings are split, the upper half being secured to the lower with studs and nuts.

Lying on the stand at the right (Fig. 5) is a steel bar, rectangular in cross section, with a small metal spline projecting from one edge. This bar is placed on the knife edge so that the point of the spline is close to the edge of the turbine wheel. The wheel is then turned over by hand

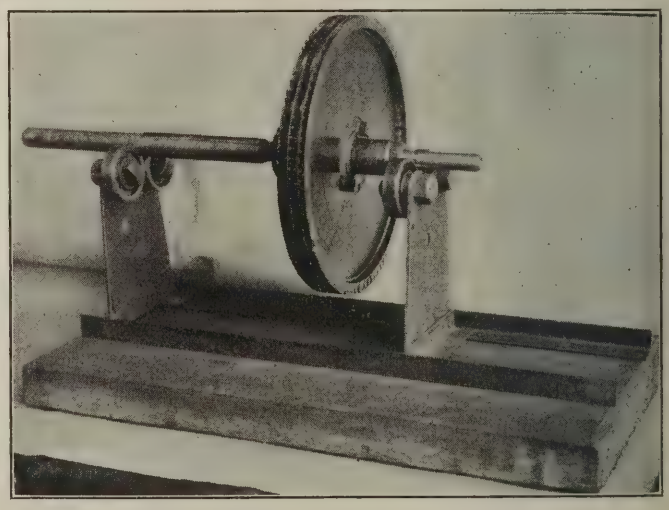


Fig. 6—Device for Preliminary Balancing

and the relative movement of the edge of the wheel to the spline will show whether the wheel is true or not. If the wheel is not true it is taken out of its mounting and returned to the block shown in Fig. 1 for further straightening.

The valve and nozzle shown at the back in Fig. 5 are connected to the air line and after the wheel has been turned

and balanced, the air is used to run the wheel at a speed equal to or greater than the regular operating speed and the wheel is thus tried for vibration. If the balancing and truing has been properly done and the governor has been properly assembled, there will not be any excessive vibration.

One of the shafts used for balancing wheels has its ends turned down so that one end will fit inside of a valve cage and the other end will fit the inside of a governor sleeve.

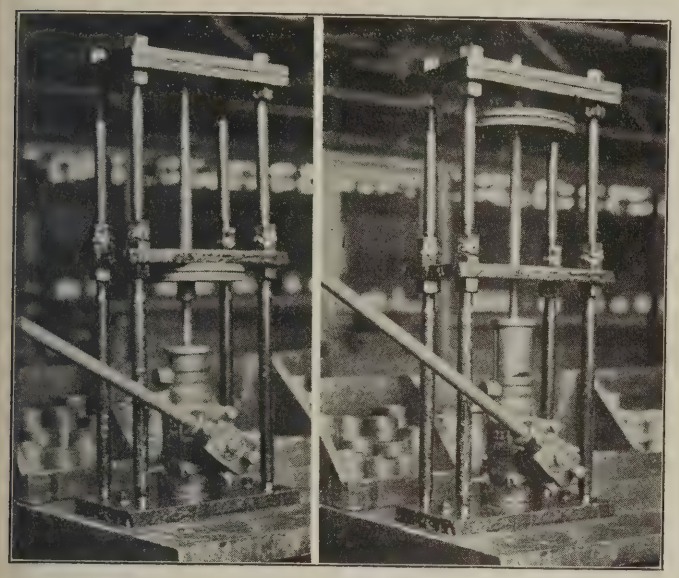


Fig. 7—Press for Removing and Applying Turbine Shafts

The wheel and shaft are run at a good speed and the valve cages are cleaned and the governor sleeve faces are polished with emery cloth as they rotate with the shaft.

The device shown in Fig. 6 is considered a very useful one in the shops and is used for obtaining a preliminary balance. It consists of two pairs of ball bearings, which do not touch each other, mounted on the two uprights as shown. One of these uprights is bolted to the base while the other is free to slide back and forth in the two angle

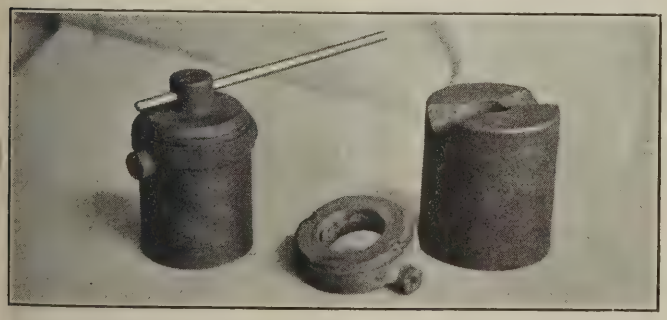


Fig. 8—Squeezer and Anvil Used Respectively for Applying Anti-Friction Rings to Ring Holder and for Chipping Out Worn Rings. A Holder with Ring Applied Is Shown in the Center

iron guides which in turn are mounted on a base made of two inch plank. The movable upright provides for different types of turbines with shafts of different lengths and the work can be done so well that further balancing on the knife edges is often unnecessary.

Shafts are applied and removed from turbine wheels in a device which is known in the shop as a two stage amplifier. This is shown in Fig. 7. It consists of a 25 ton jack set in a framework made of 1-in. steel plate and 1-in. rod. Holes in the top and center plates will permit the shaft to slip through but will stop the wheel hub. The method of removing a shaft from the wheel is shown at the left in Fig. 7, and at the right the device is shown as it is used for pressing the wheel on the shaft.

Governor Arms

The repair of broken governor arms is a relatively simple operation. It consists of welding a piece of scrap brass on in place of the broken arm after which the brass is shaped with a file.

Anti-Friction Rings

A squeezer and an anvil are shown in Figs. 8 and 9. When an old anti-friction ring is to be replaced by a new one, the anvil shown at the right in Fig. 8, is placed in a vise so that it rests on the lower jaw slide. The ring holder is then placed on the anvil as shown at the right in Fig. 9 and the vise tightened on the bosses of the ring holder. The ring holder is thus held firmly down on the anvil and the anvil cannot be displaced because the ring holder fits into the recess in the top of the anvil. A hammer and chisel are used to chip out the worn ring.

The squeezer dissembled is shown in Fig. 9. After the

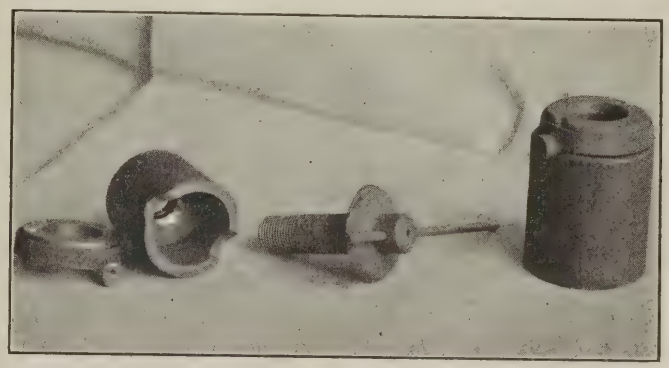


Fig. 9—Anti-Friction Ring in Holder, Two Parts of Squeezer, and Anvil with Holder and Ring in Place

old ring is chipped out, the ring holder is filled about one-third full of Smooth-On cement. A new ring is put in the holder on top of the cement and the holder and ring are then placed in the squeezer as shown at the left in Fig. 8. Turning down the handle of the squeezer pushes the ring into the cement and a stop allows the screw to be turned down to a certain point so that the ring assumes exactly the correct position in the holder. In this position it projects ⅛ in. from the holder. Part II of this article will describe the repair of governor valves, nozzles, turbine cases, generator frames, shafts and governor springs. It will also include the method of assembling and testing.

Skill, Initiative and Perseverance Rewarded

A NEW method of giving recognition to the constructive work of factory employees in industry has recently been put into effect by the General Electric Company. At the various plants of the company a short time ago workmen gathered about a platform, and the works' manager called a few of their number forward and presented them with a sum of money and a certificate acknowledging their contribution to the progress of the electrical industry.

These awards, comparable to the honors conferred upon

engineers by electrical societies, were made by the Charles A. Coffin Foundation, named in honor of the founder of the company, which was established for the broad purpose of stimulating progress and public service in all branches of the electrical industry—public utilities, electric railways, among graduate students doing research work, and finally among employees.

So far as is known this is the first time that employees in any large industry, particularly workers in the shops, have been publicly recognized for work they have done for the industry outside their ordinary duties.

Take, for instance, the tipless mazda lamp. These are coming into general use now, and probably many a person who bumped his head on a sharp tip or knocked it off and smashed the lamp, has blessed the person who removed them. There are manufacturing advantages, also, in not having the tip. The problem of how to remove it puzzled engineers for many years, but it was not until two foremen in the National Lamp Works, Louis E. Mitchell and Arthur J. White, both young men, turned their attention to it, that a solution was found. That is one instance, many times repeated, in which a man in the shops was found to have done unusually able work of value not only to his company but to the community.

The multiplicity of these achievements, known to only a few in an organization as large as that of the General Electric Company, was the source of astonishment to those who had the task of examining the many claims for recognition which came in from the various works. W. W. Trench, secretary of the Foundation, after his study of the claims found that the outstanding ones embodied three definite qualities, all of which were necessary to success —skill, initiative and perseverance.

There were also two general conclusions to be drawn from the records submitted for awards. The first was that a large proportion of all industrial workers, whether at a lathe, or a soldering machine, or in the draughting room, are doing their work with their eyes open and their minds alert to the possibilities of improving their methods, not so much in the hope of a reward, but because of the sheer mental pleasure they obtain in solving a difficult problem. The general level of intelligence was found to be high. Of course, the majority of workers in the electrical industry are necessarily skilled men, but there is no reason to believe that a survey of any similar industry would not show a similar mental attitude.

The second conclusion reached was that a majority of those who show initiative of a high order are men who naturally co-operate most successfully with their fellow workers. A man of individual brilliance who keeps his knowledge to himself and does not use it to improve his own work and his own position, or the work and positions of his fellows, is found to do justice neither to himself or the organization of which he is a part. The social interdependence of men, in the shops was as obvious in this respect as in any other. The necessity for co-operation was shown time and again where two or more men worked out together problems which individually they might not have been able to solve, and the result of this co-operation was stimulating to all about them.

There were others than factory workers included in the awards, for the employees were divided into five classes—shop workers, foremen, engineers, commercial and administrative employees.

"We found it necessary to make this division into classes that each might be considered on its merits, for if all employees had been considered as members of one class it would have been impossible for the shop worker of limited activities to compete with the engineer or laboratory men dealing with fundamental problems," said Mr. Trench. "Much credit goes to the man who accomplishes something despite the limitations of his situation. It was that which the Foundation wished to recognize and stimulate.

"A man at a lathe who re-designs a tool, for example, has a better chance to get an award than the toolmaker, for it would be part of the latter's job to make his tools as good as possible. He would have to do something revolutionary in his line to obtain recognition, or suggest improvements in other lines of work. Incidentally, many of the awards go to the men who contributed to work with which they did not ordinarily come in contact.

"This same limitation applied to engineering, and to commercial and administrative workers. The one woman who obtained an award, for instance, did something so entirely outside of her regular work that it demanded recognition. Emphasis at all times was laid on the stimulating of men to look beyond the immediate demands of production. One manager said to me of a man proposed for an award. 'He not only attends to whatever comes to him, but follows to the end every thought suggested by what passes over his desk.' It is that constant effort to do something better which we wished to seek out and acknowledge."

Three-Car Articulated Train for Department of Street Railways, City of Detroit, Mich. This Is the First Three-Car Articulated Train To Be Used In This Country and Is the Only Electrically Propelled Train of Its Kind

Head-End Car Lighting System of the St. Paul

Unique Practice Differs in Many Respects From Standard Axle Lighting Methods

By C. R. Gilman
Car Lighting Engr. C., M. & St. P. R. R., Milwaukee, Wis.

THE electric lighting of passenger trains of the Chicago, Milwaukee & St. Paul is handled by the head-end system in contrast with the individual car axle-system, for two very good reasons. First, this road owns and operates its own sleeping cars and is therefore responsible for the lighting of the entire train. Second, this road operates a number of solid trains on one night runs between Chicago and Omaha, Kansas City, Sioux City and the Twin Cities and also the through trains from Chicago to the Pacific Coast which

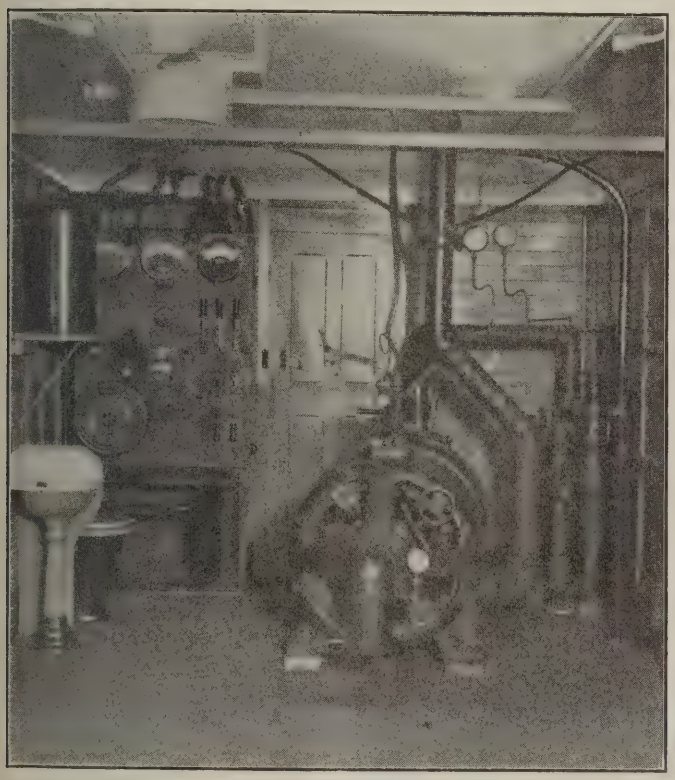


Fig. 1. Standard Turbo-Generator and Switchboard in Head End of Baggage Car for Through Trains

are run all the way without being broken up. Each train has a 64-volt, 200-amp. steam turbo-generator in the baggage car supplying energy to a 3-wire train line. In order to supply energy for the lights when the locomotive is cut off a battery is located on two or three of the sleeping cars in a train.

The Chicago, Milwaukee & St. Paul has a total of 1,044 cars wired for electric light, 191 sleepers, 46 dining cars, 30 parlor cars, 44 composite cars and 447 coaches and the rest, mail and express, mail and baggage, and straight express cars. Of this number there are 229 of the sleeping, dining and parlor cars equipped with a 32-cell, 64-volt, 300-ampere-hour battery. Also there are baggage cars with such a battery. Of these sets of batteries 221 are of the lead type, 165 sets having lead tanks and 56 sets having rubber jars, as it is the policy to replace the lead tanks with rubber jars as fast as the lead tanks are worn out. Of the entire equipment eight cars have the Edison type storage batteries. None of the coaches is equipped with batteries. These batteries are floated on the line and receive the major part of the charge during the latter part of the night enroute after most of the occupants of the sleeping cars have retired.

For the lighting of the trains there are 68 head-end turbo-generators having a capacity of 200 amp. at 64 volts. The problem of keeping these machines in operating condition so as to meet all schedules, requires careful maintenance and quick repairs.

In 1921 a movement was started for lighting branch line trains by electricity from the headlight turbo-generators on the locomotive. The majority of the locomotives were equipped with the Type-E, 32-volt, 1,500 watt turbine generator. These machines will successfully light one standard coach using 650 watts, and one mail and express car requiring 225 watts. These with the lighting required on the locomotive, 340 watts, make a good working load for the Type-E turbo-generator. There are at this time about 43 branch line trains on various divisions lighted in this manner.

There are in addition 16 suburban trains operating out of Chicago lighted by Type-T, 64-volt, 2,500-watt locomotive headlight turbo-generators. A larger machine was found necessary in this service and 64-volt generators were decided on so that the standard 64-volt train lighting lamps could be used. This service with the Type-T, 64-volt, 2,500 watt turbo-generator is being extended from time to time as occasion demands.

Train Lighting as Affected by Train Operation

On the short train-runs with the cars standing much of the time with lights on, the batteries do not get enough charge. This fact is especially true on diners and parlor cars on short runs, therefore charging equipment and yard circuits are provided in the coach yards at the principal terminals such as Chicago, Minneapolis, Milwaukee, Council Bluffs and Tacoma.

In making up through trains it is an established rule that at least three battery equipped cars be included (*i. e.*) one baggage and at least two of the other cars such as diners, sleepers or parlor cars. Under the present operating conditions it is found that three batteries are not enough, and that really four batteries are needed in each of the longer trains to handle the load in order to prevent the batteries from being too nearly discharged while in train service.

Majority of Running Repairs Made at Chicago

Practically all of the ordinary running repairs to batteries, turbo-generators and other lighting equipment is handled at the Western Ave. coach yard in Chicago.

Battery equipment is given a general overhauling when the cars go through the car shops at Milwaukee, however, a great deal of the battery washing and overhauling is done at Chicago.

On the average, three sets of batteries, of 32 cells each are handled every week in the Chicago battery room, a general view of which is shown in the picture. A rather unique air hoist, *H*, in Fig. 3, is used to lift the batteries up on the bench, and also to pull the assembled units out of the tanks in case they do not lift readily by hand. This air hoist has a three-way valve operated by hand cords so that a load can be lifted, lowered or held still at easy control. This hoist is suspended by a wheel that runs on an over-head track that permits a transfer of the battery from a truck over to the washing table or vice versa. A pulley with a single pull rope, as shown, is also used for this same purpose on lighter loads.

Reclamation of all usable materials being a practice on this road, a rather unique battery terminal mold for reassembling battery plates was designed in this shop, and has been copied by several other roads. As shown in Fig. 4 the plates are stood up in the wooden frame so as to secure the proper spacing. The mold is then fitted over the old stubs of the plates and clamped down. When all is ready, as shown in Fig. 5, the molten lead is poured into the funnel. After cooling, the mold is removed in

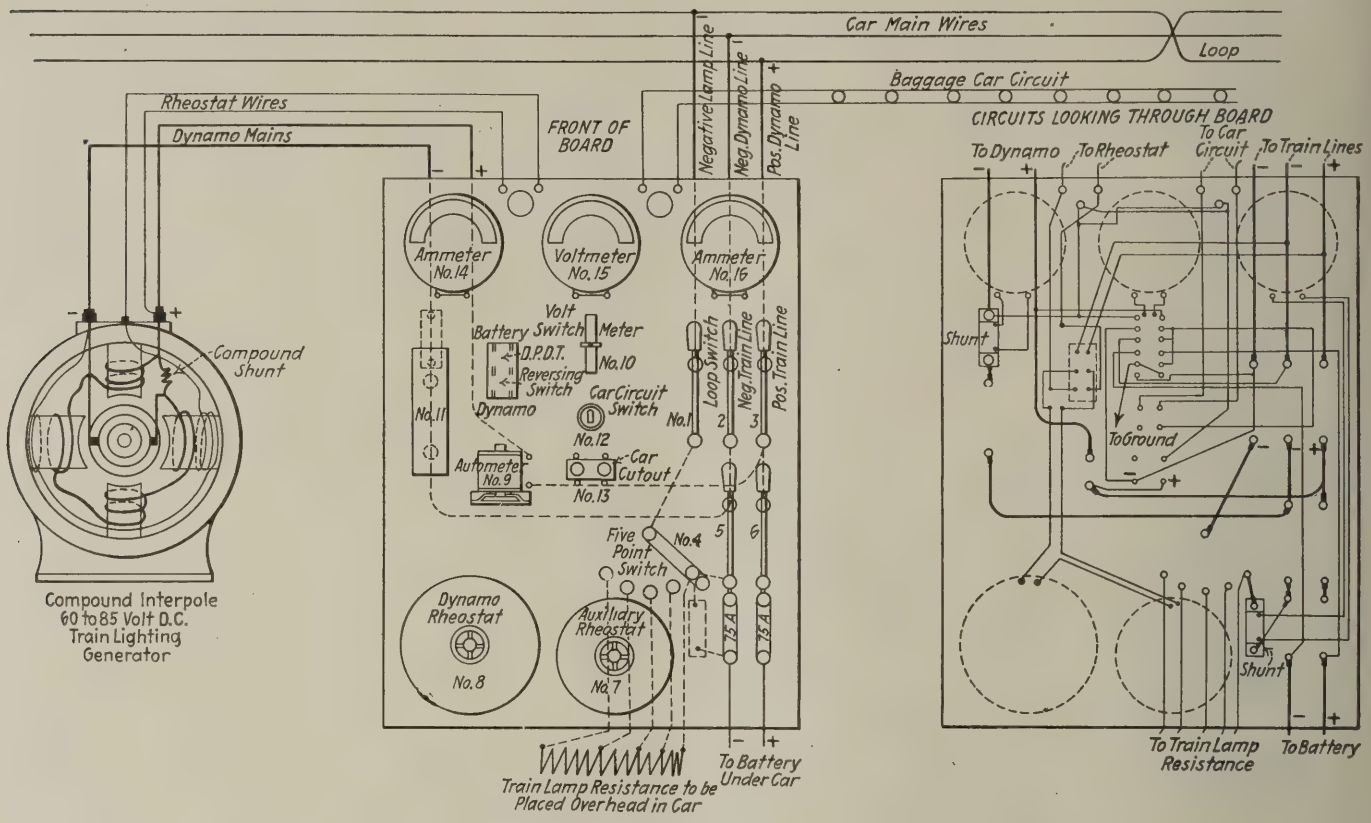


Fig. 2. Arrangement of Circuits for Switchboard and Generator in Baggage Car

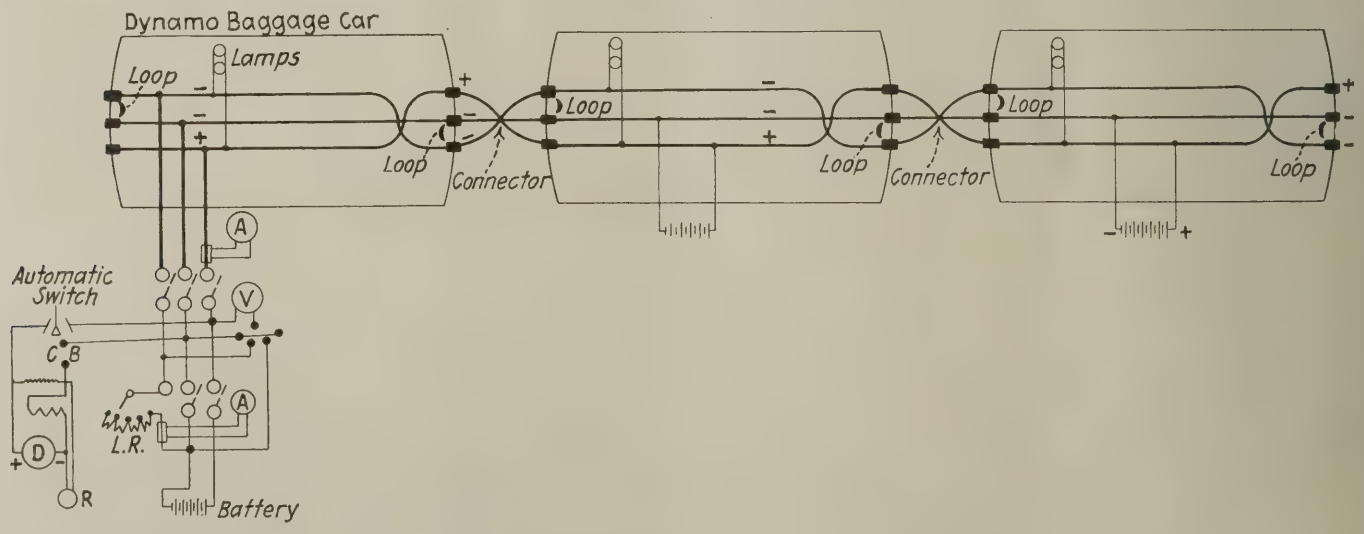


Fig. 2a. Diagram of Main Wires in the Head End System

sections and the rough edges are filed off the assembled group unit. It is then ready for service in one of the cells being assembled.

Another interesting device in use at this shop is a

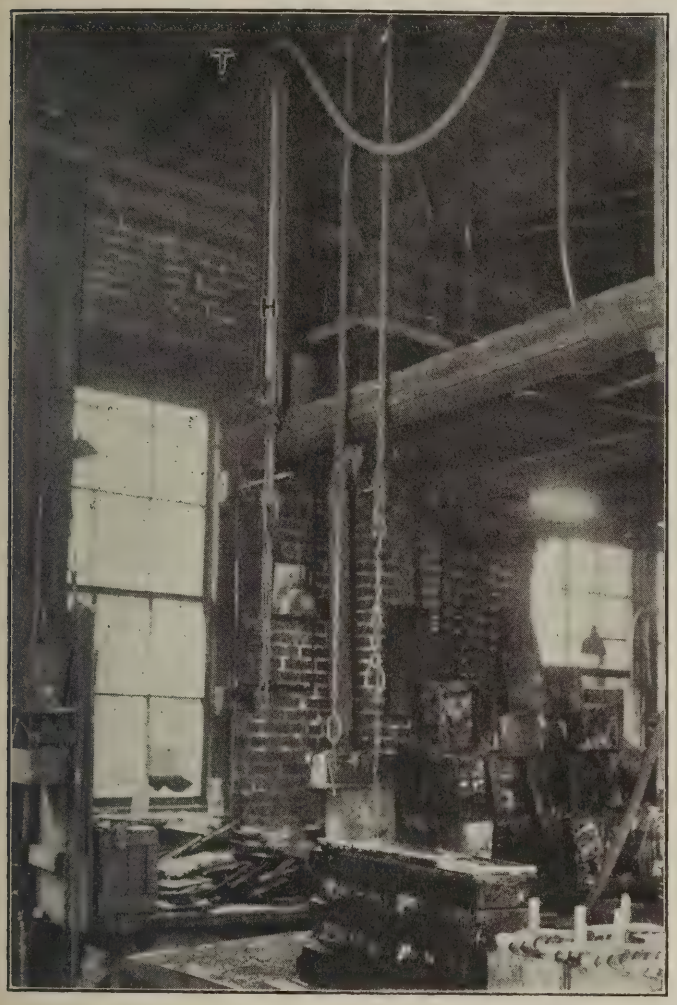


Fig. 3. Interior View of Battery Repair Room, Chicago

home-made power-driven drill press that handles a great deal of small drilling and saves a great amount of labor.

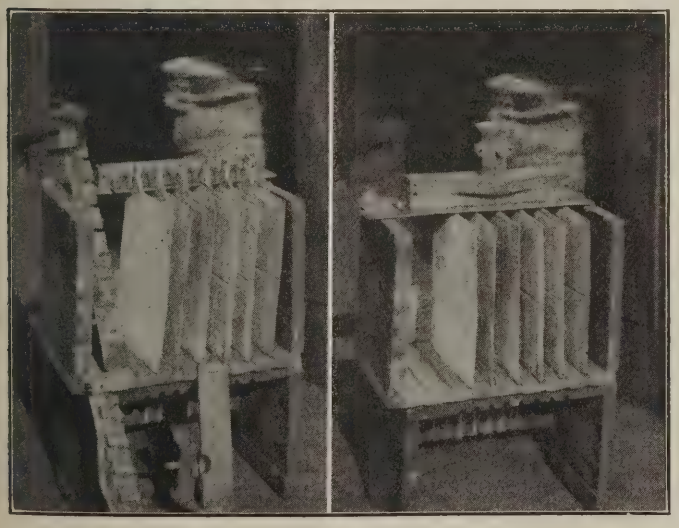


Fig. 4 Fig. 5

Fig. 4. Frame for Holding Battery Plates in Position Together With Parts of Mold

Fig. 5. Mold and Assembly of Plates Ready for Metal to be Poured

As shown in Fig. 6 the drill is carried in a chuck attached to a threaded spindle that can be forced down by turning the hand wheel. An old 110-volt d.c. signal motor drives the spindle by a set of simple bevel gears. The entire device is built upon a simple frame-work fastened to the wall.

Electric Fan Repairs

Most of the minor repairs to electric fans used in sleeping cars, diners, etc., are also made in this shop and the special testing equipment used for this purpose is shown in Fig. 7. Special plugs, fuses, switches and regulating resistance lamp bank, facilitates the testing

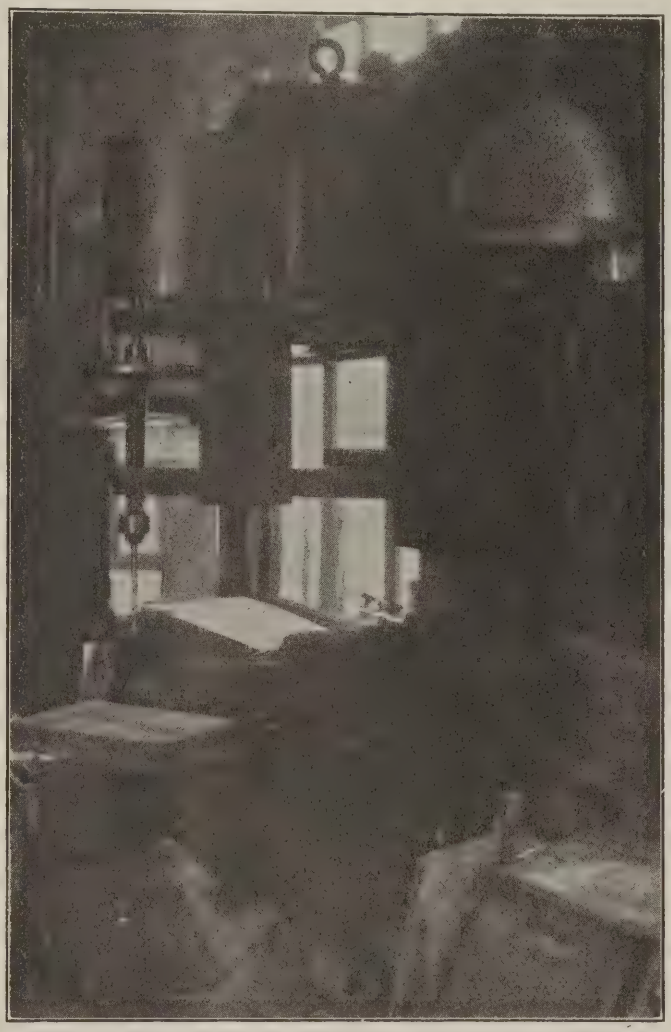


Fig. 6. Home-Made Power Drill Press Saves Time

of the fans and the Weston volt-ammeter at the top of the board ensures accurate readings.

As a source of energy for the yard charging lines the motor-generator set shown at the rear in Fig. 8 has been used continuously for the past 18 years, operating 24 hours a day a large part of the time. An unusual record has been made by the bearings of this machine as the original bearings are still in service. The motor end of this machine is 220-volts d.c. and the generator is 95-volts with a capacity of 40 kw. In the winter between 4:30 p. m. and 5:15 p. m., at which time many of the evening trains are being lighted just before being pulled out, the load is too heavy for this single machine and therefore a second motor-generator shown to the

left has been added for additional service. This machine has a 110-volt, 200 amp. generator and is used especially to maintain a charging voltage on the charging outlet farthest removed from the charging plant at the shop.

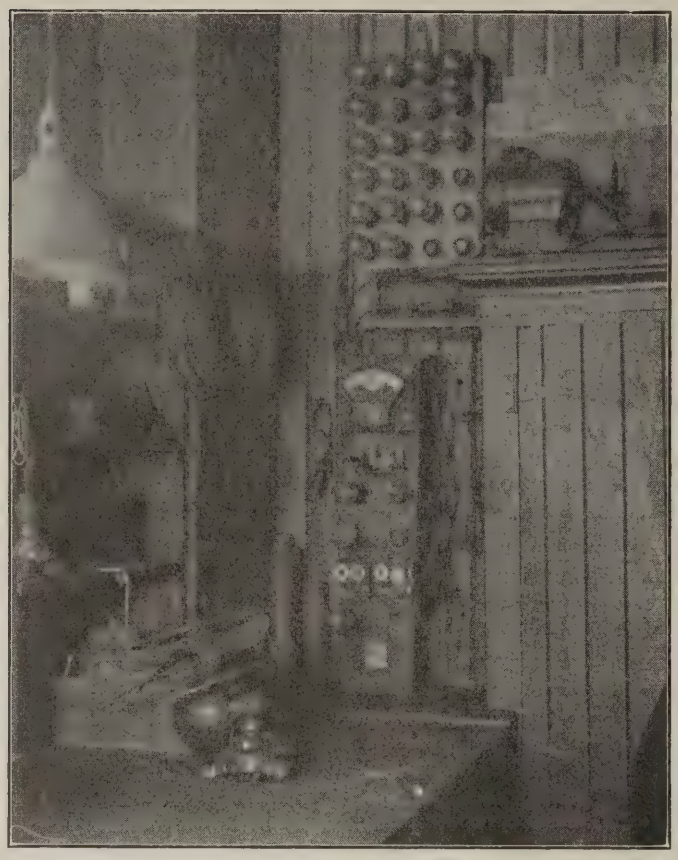


Fig. 7. Special Test Board Rheostat and Meters Used for Repairs and Tests of Electric Fans

The charging control switchboard is shown in Fig. 9. The starting apparatus for the two machines is on the end panel at the right. The rheostat handles for controlling the charging on separate circuits are mounted just beneath the meters while the single-throw single-pole switches and fuses at the bottom of the board are for the separate charging yard circuits, the positive side of the machine being common to all circuits. This board was designed and constructed by local forces some years ago, and while not modern, has the same characteristics of a modern board. Connections are made from this board into the battery room and sets of recleaned and repaired batteries are charged and tested on the benches, before being put into service.

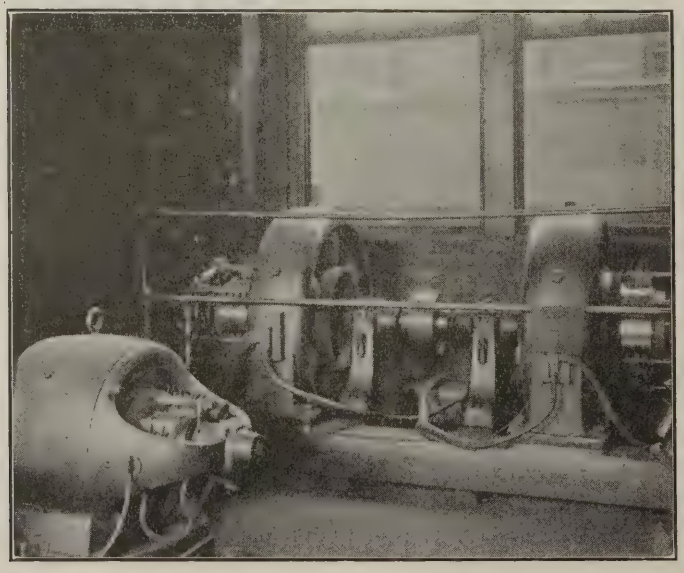


Fig. 8. Large Motor-Generator Set in Rear Has Operated 18 Years Without Change of Bearings

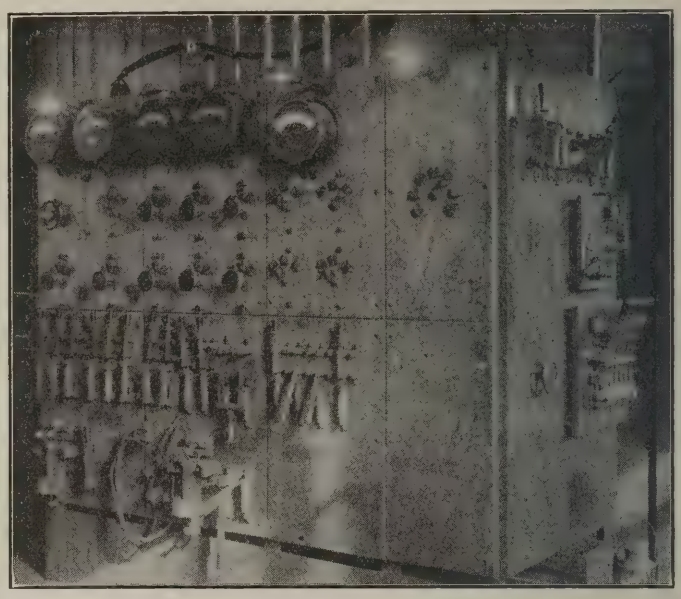


Fig. 9. Switch Board for Battery Charging and Car Lighting Circuits at Western Ave., Chicago Coach Yards

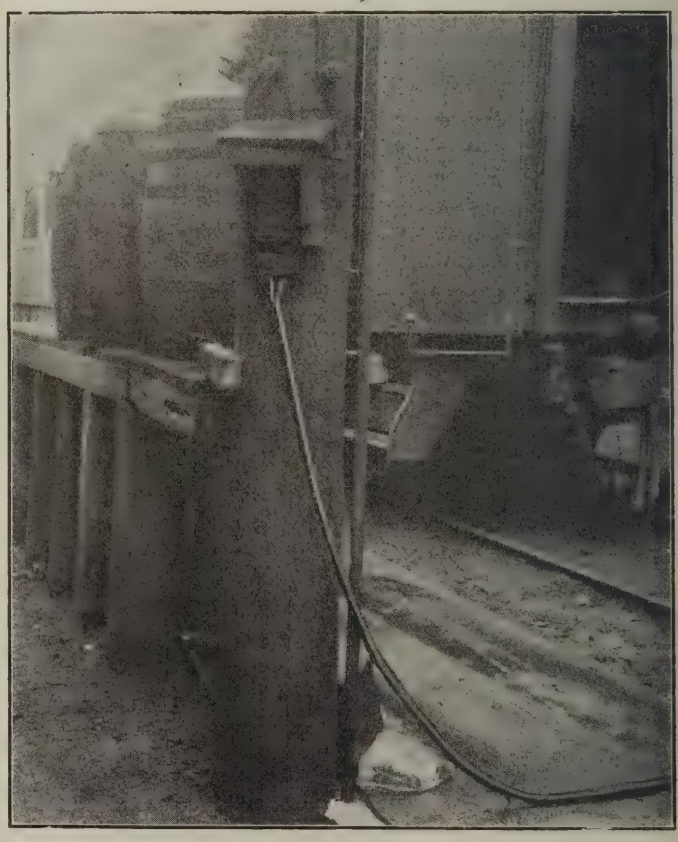


Fig. 10. Charging Outlet in Yard, Shown With Flexible Front Cover Removed from Box

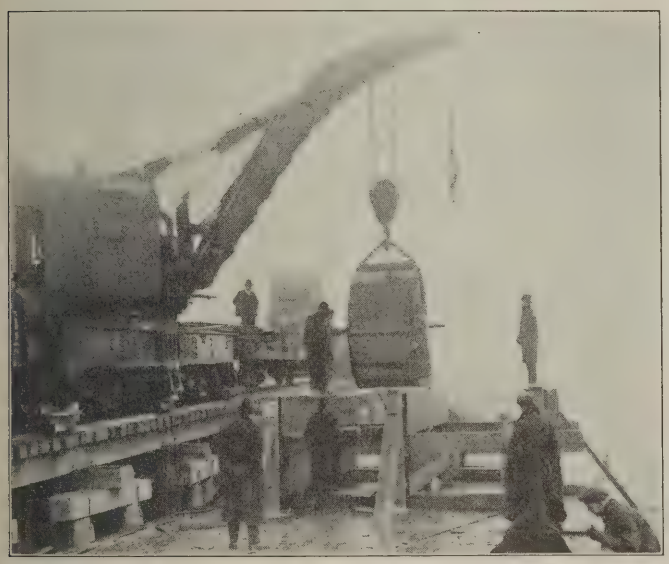
Laying Submarine Cable Across the Mississippi

Missouri Pacific Solves Power Problem and Gets Better Service at Lower Cost

By Louis D. Moore
Electrical Engineer, Missouri Pacific Railroad Co.

AT Dupo, Illinois, about ten miles south of East St. Louis, is located one of the largest and most important freight yards on the Missouri Pacific system. The yard is about three miles long, with engine terminal and car repair yard, and cars are switched over a double "hump," utilizing gravity for operation across the scales and into the classification yards.

The electrical facilities consist of a rather extensive yard lighting system, approximating 75 kilowatts, usual



Transferring Cable Reels From Car to Barge. Each Reel Was About 9 Ft. in Diameter and Weighed About 30,000 Lb.

building lighting, and motors for turntable, coal chute, shop, wells, etc., aggregating at present about 225 horsepower.

The power plant, which was installed about fifteen years ago, contained two 100 kw., 440-volt, 2-phase Stanley inductor type alternators, direct to Westinghouse vertical engines, two direct connected steam exciter sets, and two small motor generator sets for charging storage batteries used for operating the controls of the hump switches.

For several years the generating plant had not been satisfactory. The load had grown until it was too great for one machine to carry properly, and it was impossible to parallel the two machines due to their very unstable characteristics. As a consequence the voltage fluctuated very widely, a curve drawing voltmeter chart taken at the switchboard looking more like a load chart than a pressure chart, varying from 320 to 480 volts. This likewise resulted in unsatisfactory operation of apparatus, particularly the reversing and brake controls on the coal chute. Furthermore, no additional load could be carried, so that it was necessary to arrange the pump motors so that only two could be operated at once, and when additional machinery was to be installed in the woodworking plant it was necessary to install an oil engine to operate it.

New generating equipment had been considered for some time, but the cost of adequate capacity was considerable and funds were not available for it.

Dupo is across the Mississippi River from the extreme southern part of St. Louis, and about three miles east of the river. It therefore occurred to the writer that possibly current could be purchased from the Union Electric Light & Power Co., of St. Louis, and transmitted to Dupo, by means of submarine cable and transmission line, cheaper than additional generating capacity could be installed in the Dupo power house. Although an interurban line passes through Dupo, a previous investigation had shown that it would be undesirable to attempt to obtain power therefrom, as frequency changers would be needed and the rates were not favorable, besides the fact that the service was somewhat unreliable. A favorable rate for current was found to be obtainable from the Union company, and the cost of submarine cable and transmission line was estimated at little over half that of new generating equipment. In addition to the smaller investment the cost of current from the electric company was very much less

Dropping One of the Anchors. These Anchors Were Two Wheels on an Axle and Were Dropped Overboard With 500 Ft. of Steel Strand Attached, the Loose End Being Supported By a Float

than it would be if generated in the railway plant. The management accordingly authorized the expenditure in the summer of 1922, and order was immediately placed for the cable.

In considering the installation of this cable, it was found desirable to have some means of communicating across the river, and a small telephone cable was at first figured on, with the idea that after construction work was finished it could be used to communicate between the two car ferry landings at this point. However, J. C. Browne, superintendent of telegraph, decided that a telephone cable at

this point would be useful in connecting the private automatic telephone exchange at Dupo with various yard offices in South St. Louis, so it was decided that a 15 pair cable should be installed at the same time as the power cable.

The transmission voltage available was 13,200, and No. 6 conductor was deemed large enough to carry the load for some time to come, as cable of this size is rated at 450 kva. It was at first supposed that it would be necessary to make a splice in mid-stream, and we were accordingly very much pleased when the cable manufacturer advised that this cable could be made in one piece 3,000 feet long.

It was hoped to get this cable in the river before winter, but due to delay in manufacture it was not received until the latter part of December, 1922. This was bad, because of the danger of floating ice in the river interfering with the laying of the cable. A United States Engineering Department barge was chartered and as the water near the east shore was shallow the harbor boat "Erastus Wells" of the City of St. Louis was rented to handle the barge. This boat, in addition to being of shallow draft, is a "side wheeler," which was of advantage in handling the barge.

Tied Up on the East Bank, Pulling the Shore Ends. Note the Main Trench and Lateral Anchor Trenches, Also Lightning Arrester Station and Transmission Pole Line in Background

A cribbing of bridge timbers was erected on one end of the barge to receive the cable reels, and on January 20, 1923, the reels of power and telephone cable were transferred to the barge, using a wrecking crane.

These reels were each approximately 9 feet in diameter and weighed about 30,000 pounds apiece. They were the largest reels ever shipped from the Perth Amboy factory of the Standard Underground Cable Company. The cables were each about 3½ inches in diameter.

On account of the long shore pulls on the east side it was thought best to start the actual laying of the cable from that side. However, as there was no suitable place on that side to transfer the reels to the barge, the barge was tied up beside the incline to the transfer ferry, as shown in the picture, so that the wrecker could be as close to it as possible. As a precaution it was decided to anchor this cable in two places in the river, the anchors each consisting of two car wheels on their axle. These were attached to 500 foot lines of ⅜ in. galvanized guy strand, and were dropped overboard, with floats attached to the ends of the lines, as the barge was taken across the river to the east shore.

As was before stated, the water near the east shore was quite shallow, there being a considerable sand bar on that side. It was with some difficulty, therefore, that the barge

Starting the Actual Laying of the Cable in the River. Note the Cables in Trench; Also Cables Passing Off Back of Barge

was pushed close enough to the bank to enable the ends of the cables to be landed.

Trenches had previously been dug on each bank to protect the cables from the edge of the water to the cable poles, and as the cables were pulled ashore they were laid in these trenches. Both cables were laid in the same trench on each shore, except that as the cable poles were approached the telephone cable was carried in a branch trench to its pole. Lateral trenches were also dug for the shore anchor lines, of which there are two pairs on each shore.

Feeding Out an Anchor Line After Cable Has Been Attached. Clamp for Attaching Anchor Line to Cable Shown in Foreground

These anchors were heavy timbers, or "deadmen," buried at right angles to the lateral trenches, and connected to the cables by ⅜ in. guy strand. Special clamps were used for attaching the anchor lines to the cables. A line attached to the steam winch on the harbor boat and carried through a snatchblock on shore was used to pull the shore ends and greatly facilitated the work.

After sufficient shore end of each cable had been landed the actual work of putting the cables in the river commenced. It was at this time that it was discovered that both the barge and the steamboat were aground on the bar, and it was here particularly that the superiority of the side-wheel steamboat over screw propeller tugs was apparent. By working alternately with the two side wheels the steamer was able to "rock" her way off of the bar and pull the barge free.

Four inch crossing planks had been spiked to the deck of the barge, with a considerable part extending beyond the end, to act as guides for the cables, and heavy ropes

"All Laid." Tied Up at the West Bank After Completion of the "Cruise." The Timber Guides Have Disappeared

had been looped around the cables to act as snub lines. However, when the west bank was finally reached only one of the planks was in place, and it was not found necessary to do much snubbing. Heavy planks had also been placed across the front end of the cribbing, with ends bearing against the flanges of the reels, to act as brakes, and these served their purpose very well.

The principal difficulty in placing the cables in the river was the fact that it was necessary to preserve as straight a course as possible between the two landing points and at the same time contend with the fairly swift current of the river. An absolutely straight line was, of course, impossible, and it was thought best to have the curve slightly upstream, as there was less likelihood of the barge getting out of control and wasting cable. It was also necessary to pick up the two lines attached to the stream anchors.

The actual crossing consumed about three hours, and would have taken much less time had it not been for the stops necessary to pick up and attach the anchor lines. Some idea of the holding power of these anchors may be had from the fact that one of them held the barge broadside to the current and the harbor boat as well, while the line was being attached to the cables. The crossing was uneventful, except, possibly for the tearing loose of the plank guides. This occurred quite suddenly when the barge swung around at an angle with the stream, and very nearly took a man or two overboard. Had it not been for a heavy mooring iron and capstan on the barge, which caught the cables, serious damage might have resulted. Before the Missouri shore was reached the drum of the power cable reel became visible and there was just a little nervousness on the part of several that the end of the cable would be reached before the shore was. This fear, however, proved to be entirely groundless, as there was plenty of end left for all requirements.

The west bank was reached about 4 o'clock, and the barge tied up. Everyone was glad to be back in Missouri again, as there had been no stop made for lunch and the work of handling the cable had at times been rather strenuous. As nothing could be accomplished toward landing the west shore ends in the short time remaining that day, it was decided to "call it a day" and finish up next day.

The next day we were all glad we had put the cable across the day before, for it had rained lightly during the night and frozen, so that the deck of the barge was quite slippery. As a matter of fact, the day the cables were put down was the last day for three or four weeks that the installation could have been made, due to weather and river conditions. The Missouri shore ends were landed the day after the cables were laid in the river, and shortly afterwards the cable terminals were applied by an expert from the cable manufacturer.

Land Line Connections

Current is received from the electric company on the Missouri shore at the point where the cable ends. As previously stated, the voltage is 13,200, and the cable is protected against lightning and other disturbances by oxide

Installation of Switches, Lightning Arresters and Meters at the Junction Point Between the Power Companies' Lines and the Western Terminal of the Submarine Cable

film lightning arresters, connected to the line through the usual disconnecting switches. A General Electric FKO-36 25,000-volt oil circuit breaker, with three-coil trip, serves as protection against overload, short circuits and grounds. The electric company, as usual, furnishes the metering equipment, which at present is supposed to be a temporary equipment due to non-receipt of the regular equipment. This equipment is all mounted on a platform, carried on poles, about fifteen feet above the ground, so as to be above high water.

The eastern end of the cable is likewise protected by an oxide film arrester, mounted on a platform supported by two poles. A delta-star pole-top disconnecting switch, gang operated, is located between the cable and the over-

head line, choke coils being provided at the cable end.

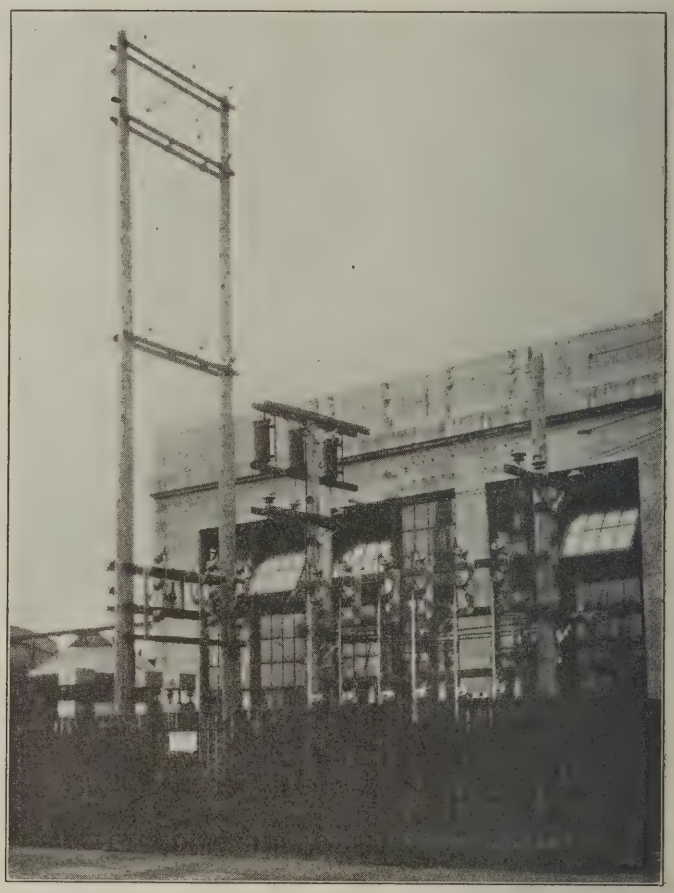
The transmission line extends from the east bank of the river a distance of about three miles to Dupo, where the transformer station is located. The line is insulated nominally for 35,000 volts, the insulators having a dry flashover of approximately 100,000 volts. The conductors are spaced 36 inches apart, minimum, being carried on one crossarm with two conductors on one side and one on the other side of the pole. The conductors are No. 6 gage, medium hard drawn copper wire, according to specifications of the American Society for Testing Materials. Pole spacing varies, with a maximum of 187 feet and a normal of 175 feet. The line poles are 35 feet, but higher through Dupo, while over the hump 75 ft. poles were used.

The transformer station at Dupo is located just outside the power house, and consists of an oxide film arrester, a General Electric FKO-36 15,000-volt oil circuit breaker with external tripping transformers, and three 150 kva. 13,200-volt primary to 440-volt secondary transformers, connected delta-delta. The transformers are connected to the high and low tension busses through disconnecting switches, so that it is possible to isolate any transformer for repairs or otherwise with a minimum of delay. As a matter of fact, the bank is being operated open delta at the present time, as the load is not large enough for economical operation of all three. The "turning point" for open and closed delta operation is approximately 40 per cent of transformer bank capacity. The oil circuit breaker is operated from the switchboard in the power house by means of remote manual operating mechanism.

Junction of the Eastern Terminal of the Cable with the Overhead Power Line to the Dupo Shops

One of the old generators, with its exciter, was retained and solidly connected to a Scott connected bank of transformers, so that three-phase current from the generator might be available in case of failure of the outside power.

The old switchboard, which was unsuited to the new installation, and very "messy" besides, was replaced with an entire new board, consisting of an alternator and exciter panel, an incoming line panel, two lighting feeder panels with lever switches, two 2-circuit oil breaker panels for yard lighting circuits, a motor-generator panel for the charging generators and three double circuit power feeder panels. All switches and circuit-breakers are 440-volt. A full complement of meters is provided, including curve drawing voltmeter, wattmeter and powerfactor meter on the incoming panel and watthour meters on all feeder panels. A watthour meter is used on the incoming line.



Outdoor Substation at Dupo Shops

As the various motors were two-phase, it was necessary to make provision to operate them from the three-phase lines. Where possible this was done by re-winding. However, some could not be re-wound for three-phase and one could not be taken out of service long enough to re-wind it. For these motors, Scott connected auto-transformers were provided.

The cable and transmission line were put into actual service on April 21, 1923, although the switchboard has only recently been completed. The service has shown a very great improvement over the old system, with a very considerable reduction in cost, even considering the overhead charges on the new work and the attendance charges, which, of course, were not eliminated. There have been a few interruptions, the most serious being recently when someone evidently mistook our insulators for clay pigeons and shot out eight line insulators and two on our pole top switch.

Train Control Company Improves Air Apparatus

Indiana Equipment Corporation Develops Valves to Give Graduated Reduction of Brake Pipe Pressure

SEVERAL developments have recently been completed in the automatic brake operation of the train control system of the Indiana Equipment Corporation, Indianapolis, Ind. Road tests of this system of train control were made on the Cleveland, Cincinnati, Chicago & St. Louis and reported in the September 1923, issue of the *Railway Electrical Engineer*. Since that time the apparatus has been developed on a practical manufacturing basis in a form more readily installed and maintained on a locomotive. A description of the functions of the different pieces of pneumatic apparatus are given herewith for the first time.

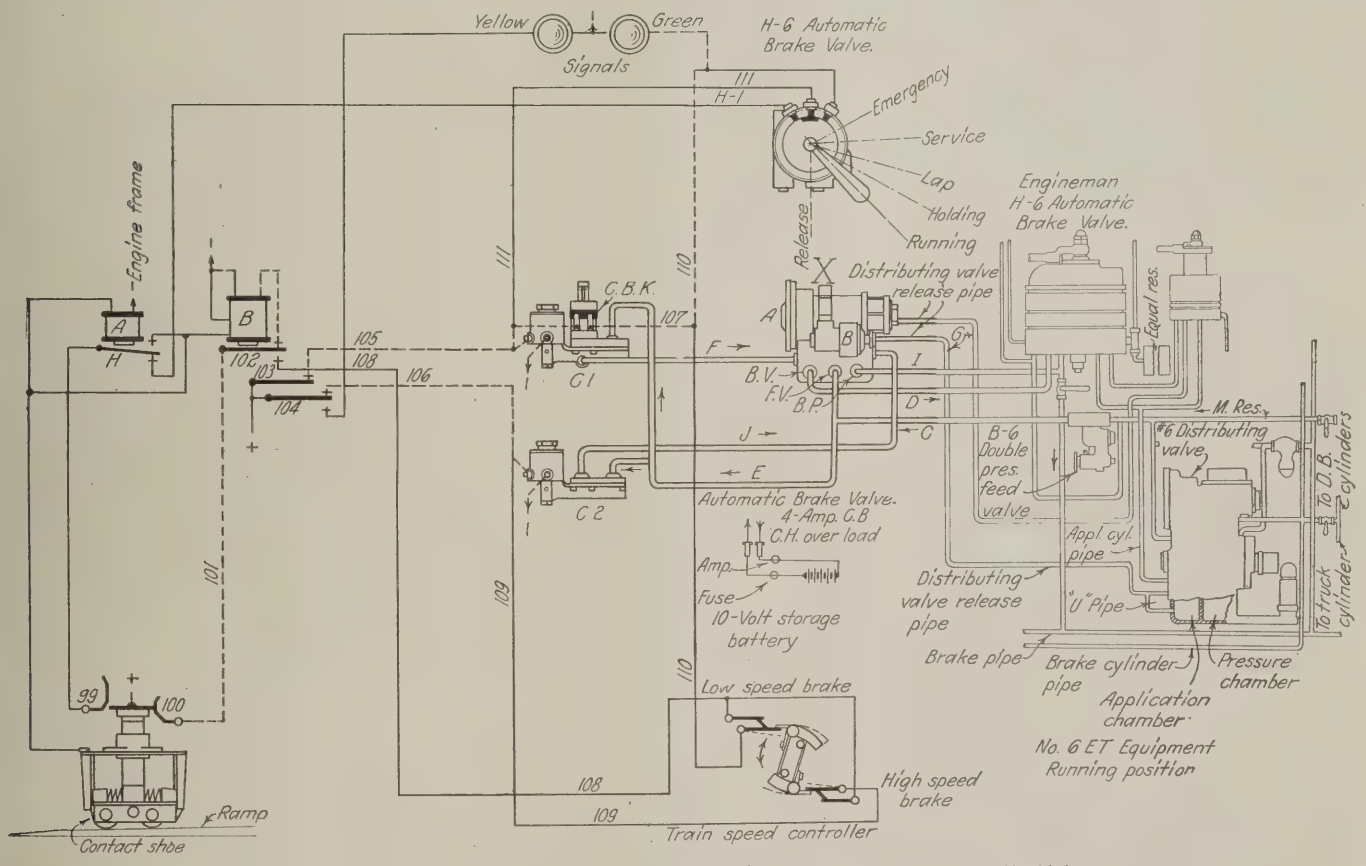


Fig. 1—Diagram of Circuits and Piping Showing Connections of Automatic Valves

Briefly, this train control system consists of an automatically operated brake valve with control features, that performs the same functions as the engineman's brake valve. This automatic brake valve is operated pneumatically, being controlled by two electro-pneumatic valves that are in turn controlled indirectly by a speed controller and a wayside ramp which is interconnected with the automatic block signal system.

Operation of Automatic Valve

In Fig. 1, the apparatus is in the charged or running position. The heart of this system, in contrast with other train control systems, is the automatic brake valve *X*. The piping shows the feed valve pressure in pipe *C* from the B-6 feed valve. Referring to Fig. 2 and Fig. 3, it is seen that feed valve pressure is maintained in cylinders *Y* and *Z*, through piping *E*, *F*, and *J*, the pipes *GG* acting as air relief or exhaust to atmosphere of any air leaking into the application chamber of the distributing valve. Feed pipe pressure enters at port *C* and passes out of port *D* to the engineman's brake valve. The pipe *I* connecting the brake pipe and the automatic brake valve is blanked off by the slide valve. Brake pipe port *I* is lapped and port *H*, the exhaust leading to the check valve, is also lapped.

Operation at High Speed

With the apparatus in the charged condition and running at high speed, a brake application is accomplished by the release of electro-pneumatic valves C_1 and C_2 when encountering a de-energized ramp at a caution or a stop signal. The valve C_1 releases and exhausts air pressure from cylinder *Y*, and feed valve pressure in the valve body forces the piston *4* to the left, carrying the slide valve with it. At the same time, magnet valve C_2 releases piston *5* (shown in Fig. 3) which moves 3/16 in., releasing the check valve. This gives a large area for brake pipe air pressure from ports *I* and *D*, connecting with port *H*, to

exhaust to the atmosphere, controlled by the limiting device. The feed valve maintaining air pressure is interrupted.

The braking system is exhausted from two ports (with the engineman's valve in the running position), through feed pipe connection *D* and through brake pipe connection *I*. Either of these ports will release brake pipe pressure to permit a brake pipe reduction of 25 lb. in from 5 to 25 sec. according to the adjustment provided. However, in actual passenger train tests at different speeds with the high speed quick action brake and with the high speed controller adjusted to go into action at a train speed of over 50 miles an hour, a brake pipe reduction of 20 lb. was made in 8 sec., using both ports in the valve, and again in using the port from the brake pipe only, by placing the engineman's brake valve in the lap position.

The selecting of high speed quick action and low speed braking is controlled by magnet valve C_2. This valve will not release at the lower speeds. A slow rate of reduction is accomplished by the check valve held in the closed relation by piston *5*, when the rate of reduction will be governed by the size of the choke plug arrangement in the body of the check valve. When magnet valve C_1 releases at low speed it results in a gradual brake pipe reduction and lengthens the time of the reduction. In the action of the limiting device, the air

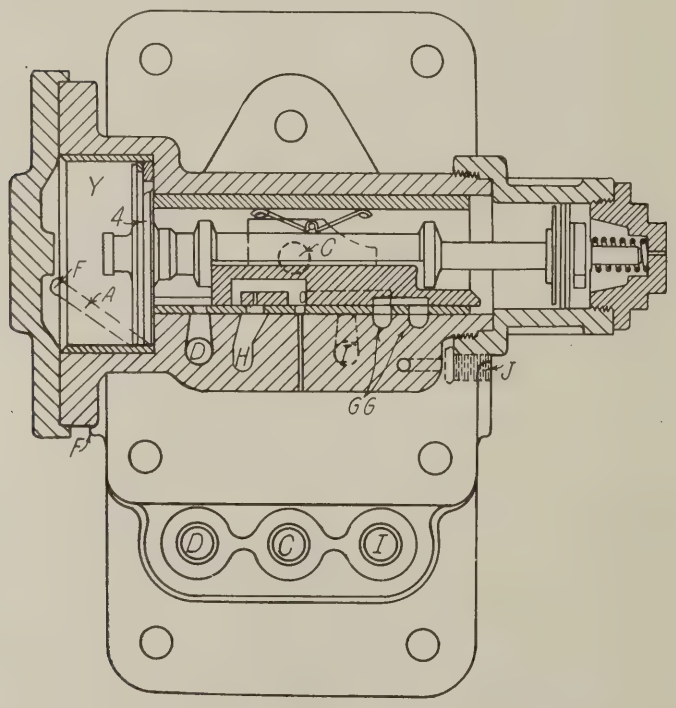


Fig. 2—Cross Section Showing Operation of Slide Valve

exhaust to the atmosphere is broken up in intermittent pop action and slows up at the end of the reduction, effecting a gradual stoppage of the brake pipe exhaust. If the engineman is alert and quickly moves the brake valve handle to the holding position, he can prevent quick action or forestall brake action when running under the low limit speed. This valve may be changed for freight or passenger service without any adjustments other than turning a hand-wheel. If desirable, this hand-wheel can be left in the release position and used as a maximum speed brake for helper engines to prevent them from being operated at too great a speed when running light.

The pressure reduction limiting valve is a modified valve as used on the distributing valve on the locomotive. An air chamber has been added around the body as well as two adjustment nuts which permit positive adjustment and slow up the pop action, thus giving the exhaust a slow start and stop.

Description of Operation

The automatic brake valve is under the control of the magnet valve C_1 for maintaining the running and charging positions and for brake application position. The

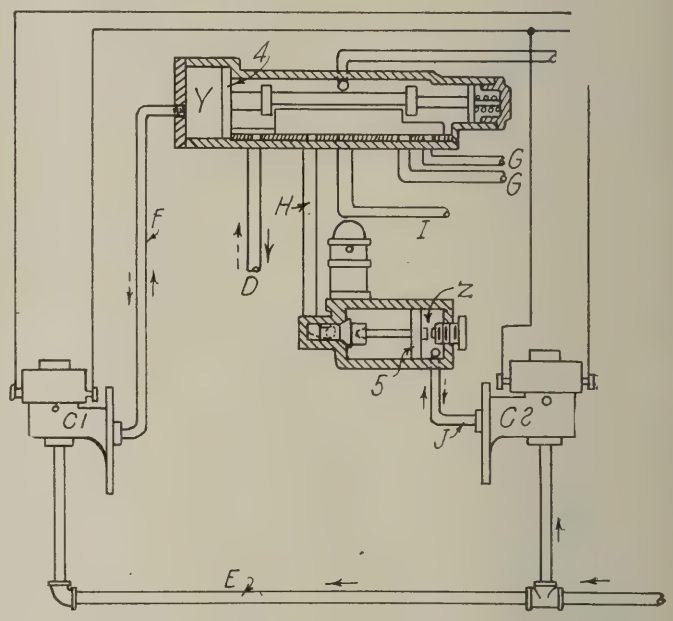


Fig. 3—Diagrammatic Connections of Control Valves, Automatic Valve and Check Valve

release of magnet valve C_2 alone will not cause a brake action.

Fig. 1 shows the braking and electrical devices in the clear set up for high speed running. The system is put into service before leaving the engine house or terminal by closing the circuit switch with the battery. Relay *B* will not pick up and the control will be set up for low speed running. Magnet valve C_2 will be energized but magnet valve C_1 remains de-energized until the engineman's automatic brake valve has been moved to the release position and back to the running position. This will set up the automatic brake valve into the running position and the brake system will be charged and the locomotive can proceed under the low speed limit of the speed controller. This set up remains for low speed until the first clear roadside ramp is contacted; if the block is clear the ramp will set up the traveling control system on the locomotive into the high speed proceed position as shown in Fig. 1.

Relay *A*, having received current transmitted from the local ramp, picks up and relay *B* is picked up, thus maintaining this section of the relay in closed relation until the shoe leaves the ramp, when the circuit of relay *A* is opened at circuit breaker *99* on the shoe and relay *B* continues to be maintained in closed circuit relation by circuit breaker *100* on the shoe controller. This closes the circuit, as shown in dots, and removes the brake control from the speed controller.

Proceeding Over Ramp with Signal Indication Caution or Stop

Assuming that the first ramp indicates caution or stop, as a train approaches with a low speed set up, the shoe contacts over a de-energized ramp; the engineman must then move his brake valve to either the holding or lap position. This move is sufficient to close the circuit to hold electric valve C_1 energized, and prevent a brake action. The circuit is energized, and positive battery from shoe breaker *99* through back point switch H of relay A during travel over a de-energized ramp. This is the only circuit that can supply electric current during travel over a de-energized ramp as the brake-maintaining circuit is opened a circuit breaker *100* by the upward movement of the shoe. This checking by the engineman is necessary over all de-energized ramps.

If a train should proceed over the home ramp of an absolute stop signal, indicating stop, a brake application will immediately follow and it will then be necessary for the engineman to break a seal and replace fuses. The advance ramp for a stop and stay signal must be located at full braking distance from the home ramp and signal. If a train should be required to pass over a ramp with an absolute stop signal indicating stop, with a caution card or other slow order, it will be necessary for a trainman to hold a circuit controller (a part of the ramp) in open relation during the shoe contact over the ramp and the engineman must hold his valve in the lap or holding position.

Low Speed Proceed Following High Speed Entrance Into Caution Block

When a train is running at a high speed, say 60 miles an hour, both of the speed controller switches will be open and the automatic brake valve functions when encountering a caution ramp and the high speed brakes are applied until the speed is reduced to the predetermined low speed limit. Both speed control operating arms are closed at this point, completing the circuits *108* to *100* to the release switch on the engineman's automatic brake valve, also through the green signal light, thus indicating to the engineman that he can release the brakes if desirable. He can then make the release in the usual manner by one or more moves with his brake valve to the release position. The first move to release position will close the circuit *110* through the switch on the engineman's valve to *111* and magnet valve C_1 to common, the circuit breaker K on the valve movement will then close the maintaining stick circuit, *110-107*. Only a momentary contact is required at the engineman's valve circuit controller to energize C_1 to complete the low speed circuit. This circuit will always be opened at *CB-100* on the shoe when contacting with a ramp and when a ramp is de-energized or on open circuit the engineman must place his brake valve on the holding or lap position to maintain the magnet valve C_1 in the closed circuit relation. This is accomplished by positive battery from the shoe controller *99* through the back point of circuit switch H and circuit H_1 through engineman's valve switch circuit *111* and Magnet C_1 to common. Referring to the circuit breaker *99* to *100* on the shoe, the *CB-100* will close before *CB-99* breaks the circuit on the downward movement. If an engineman should fail to move the brake valve to the holding position the magnet valves C_1 and C_2 will be on open circuit and release, causing a full service brake application.

Train Exceeding Speed in Permissive Block

When a train exceeds the speed in a permissive block the C_1 valve will release and a low speed brake action will result, C_2 being maintained by a circuit through the operable switch on the high speed controller. The engineman can make an immediate release and the brake action will not pull the speed of the train down to any great extent for the initial brake action is slowed up to provide for a smooth braking of the train. However, there is a different brake action for the low speed braking when the train is running above the low speed brake set up, say 40 miles an hour and approaching a de-energized ramp. When the shoe contacts a dead ramp at caution or a stop and proceed block, both C_1 and C_2 controllers release while passing over the ramp, then C_2 picks up and holds, which assists in the initial braking.

New Application of Rectifier

The Magnar battery charger, a device marketed by the General Electric Company, for the a.c. floating charging of railway signal batteries, is being applied to new fields, such as time clocks, bell systems, burglar alarms, and tripping batteries in power plants and sub-stations. It has been found that, on such installations, the batteries may be discharged continuously at a very low rate or intermittently at a higher rate, the average discharge rate being low in either case.

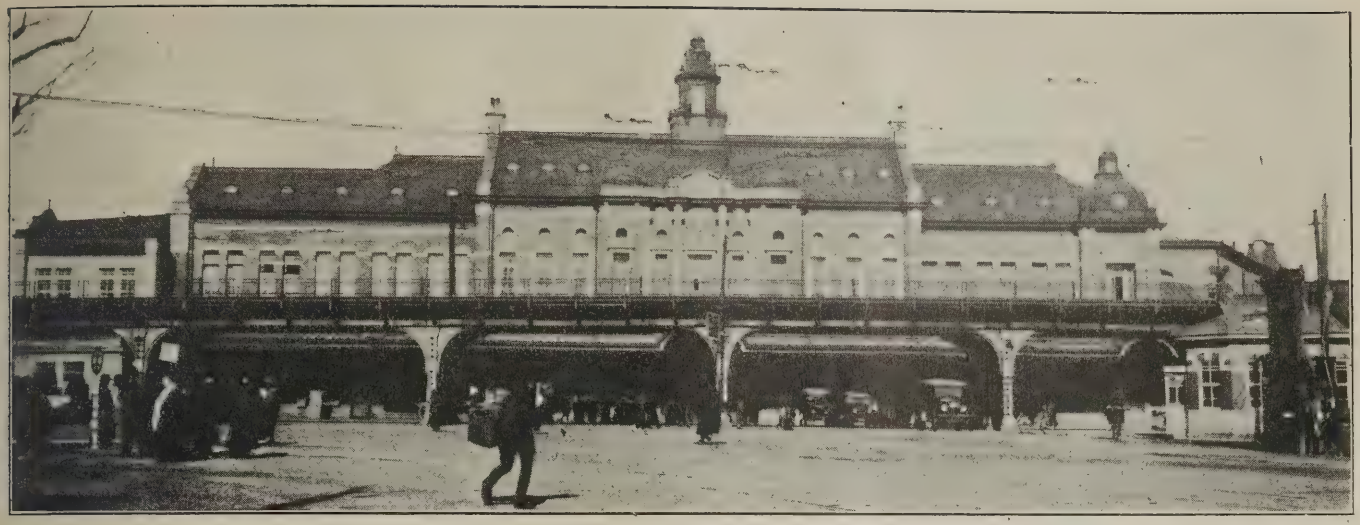
By the floating charge method, the charging equipment operates continuously. The average rate at which the battery discharges being first determined, the equipment is regulated to supply the battery just enough current to compensate for the discharge plus a small additional amount to allow for internal leakage. Among the advantages claimed for this method of charging are the continuous maintenance of a fully charged battery, a constant voltage, longer life and the necessity of a mnimum amount of required attention for care.

Seven hundred automatic telephones will be put in operation for experimental purposes by the Shanghai Mutual Telephone Company in March. If experiment is successful, a general adoption may follow.

Station on Alsace-Lorraine Railways at Metz

What the Earthquake Did to the Japanese Railways

1—Cracking and Shifting of Piers of Bridge Over Minato River, Between Kazusa-Minato and Hama-Kanaya, Boso Line. 2—Cracking and Partial Falling of Nokogiriyama Tunnel, Sobu Line. 3—Falling of Girders on Bridge Between Hayakawa and Nebukawa, Atami Line. 4—Eastern Entrance of Komine Tunnel after the Quake. 5—Looking Over Bridge Shown in First Illustration. 6—Derailed and Overturned Passenger Train Near Oiso Station, Tokaido Line. 7—Overturned Locomotives, in Engine House, Awahojo Station, Sobu Line. 8—Shifting of Roadbed Leaving Track in Original Position, Between Nebukawa and Manazuru, Atami Line. 9—Shimbashi Station, Tokyo. 10—Overturned Freight Train, Chigasaki Station Yard, Tokaido Line. 11—Collapsed Bridge Over Banyu River, Tokaido Line. 12—Passenger Train Buried When Samunomeyama Tunnel Collapsed During the Quake; Stack and Cab of Locomotive Barely Visible. 13—Train Crushed and Overturned by Falling Highway Bridge, Odawara Station, Atami Line.



Yokohama Station Used for Both Steam and Electric Service

Electrification Program for Japanese Roads*

Abundant Water Power and Limited Coal Supply Are Powerful Influences in Developing Electtic Traction

ALTHOUGH the great disaster of September 1 will naturally manifest itself in some modification of the original Japanese plan for the electrification of railroads, it is believed that such changes as may be effected will be with regard to extension of time rather than of curtailment of program. The natural resources of the country are such that the ultimate electrification of most of its roads is practically inevitable. There is a very limited supply of coal available, whereas water power exists in abundance. These two factors place Japan in very much the same position as Switzerland where so much electrified line has been placed in operation during the last few years.

Natural Resources

A fair quality of coal is mined in the islands of Kyushu and Hokkaido. Some surveys indicate that the accessible deposits will be exhausted within the next 80 years. The next source of coal supply is the Fushun collieries in Manchuria but the question of transportation will always be an outstanding objection to the use of this coal. The original hydro-electric developments were installed by small companies for relatively local power distribution. These have been gradually consolidated into larger corporations with increasing power voltage and range of transmission. There are at the present time two general systems of hydro-electric power production and transmission, one of which centers on Tokyo and Yokohama on the eastern side of the island while the other centers on Kobe and Osaka on the west. While neither of these systems is completely unified either in financial control or physical operation, they are gradually tending towards such a condition with a standard transmission voltage of 154,000 volts. According to the present plans each of the two systems, within 10 years will have an installed capacity of 1,000,000 kw. and with interchange of power between the two systems will form a super-power system connecting the chief hydraulic centers with the principal industrial centers of the island.

Traffic Congestion

Referring to the second important point, that of traffic congestion, there has been a rather intense controversy among engineers as to the best way of handling the present traffic and allow for its continual increase. It is a fact that traffic is very heavy and it has long been evident that some method of handling more traffic over these lines must be found. The present track gage is 42 in. One party has strongly advocated increasing this to standard gage, thereby giving an opportunity to install heavier motive power, heavier cars and to handle a greater traffic. This, however, would require relaying all track, rebuilding bridges and tunnels as well as rolling stock and would involve an almost prohibitive expense. As contrasted with this, electric operation of the present line would increase the speed of trains, would avoid delays at tunnels and would eliminate much of the delays in freight yards. It would, therefore, result in the same increase of capacity at a vastly less expenditure. It has finally been decided to electrify the road, maintaining the present gage of track, to adopt 1500 volts d.-c. as the standard system, and to proceed as rapidly as possible with the electrification of the principal lines.

Existing Electric Lines

The suburban lines around Tokyo are already operated electrically. The first of these lines to be electrically equipped was from Manseibashi to Nakano, a distance of eight miles. This is the suburban section of the Chuo line and was put in operation in 1905. In 1910, the Yamate Belt line was equipped for electric operation. This is a belt line running from Tokyo station through

* An abstract of a report entitled "Railways of the Japanese Empire," prepared by S. T. Dodd, railway department, General Electric Company.

Shinagawa and around the north side of the city making connections on the eastern side with the Tohoku line at Ueno station and at Akabane. This line was also equipped at 600 volts and the length involved was about 23 miles. In 1915, the Yokohama-Tokyo line was equipped for multiple unit operation. On account of the length of the suburban run and the weight of trains, it was decided to adopt 1200 volts for this electrification rather than 600 volts. The suburban lines in the city are still operated at 600 volts and the change over from 600 to 1200 is made just beyond Shinagawa station. With the adoption of 1500 volts as the standard railway voltage, there will be a change made in the voltages of these various lines. The Tokyo-Yokohama line will be considered a part of the main railway system and will be operated at 1500 volts. New motors and equipments will therefore be purchased for this line. The Chuo and Yamate lines which are now operated at 600 volts will be changed to 1200 volts utilizing the equipments of the Tokyo-Yokohama line and as far as possible parts of the present 600 volt equipment.

The city of Tokyo proper has a population of about three million, but the transportation facilities are less than for any other city of similar size. Paris which has a population of the same amount has 1020 miles of street railways, while Tokyo has only 180 miles. For a growing modern city, the street railway system is utterly inadequate and the extension of its rapid transit facilities has been the subject of much discussion and investigation. Plans have been drawn for the construction of a number of subways under the city streets. Without detailing the names of the different companies, which have applied for franchises for the construction of such subways, it is sufficient to say that plans have been made for a number of different lines. In general they all reach the center of the city near Tokyo station and the aggregate makes a system of ten subways radiating out from this point. Due to the fact that Tokyo is in an earthquake zone, the effect of earthquake on such underground structures has been

Multiple Unit Train Between Tokyo and Yokohama. Five-Car Trains Run on 12 Minutes Headway From 5 A. M. to 11 P. M.

This 60-Ton Electric Locomotive Was Built in the Shops of the Japanese Imperial Government Railways for the Shin Etsu Line. It Operates Both on Rack and Adhesion, Taking Power From the 600-Volt Third Rail. It Is Unique in That It Is the Heaviest Locomotive in Service on Any Electric Rack Railway

the subject of discussion among Japanese engineers. The consensus of opinion was that underground structures could be built to stand earthquake shocks as well as or better than surface structures. These conclusions may be subject to modification after the experiences of September 1. At least the experience of that date should give valuable data on the question of desirability of subway construction.

Future Plans

The first section of the Tokaido line to be electrically equipped will be the 50 miles running from Tokyo westward and ending at Odawara. Electrical construction and installation were proceeding along this line during the early part of 1923 and it was expected that by the spring of 1924 steam operation would be eliminated from this 50 mile section and all train movements would be carried out with multiple unit cars or electric locomotives.

The next section to be equipped will begin from Akashi the terminus of the engine division 10 miles west of Kobe

Linemen Erecting Poles and Stringing Trolley Wire for the First 50 Miles Out of Tokyo Preparatory to Electric Operation in This Section

and 385 miles from Tokyo. This will include the electrification of the suburban lines around Kobe and toward Osaka and Kyoto. This section is selected on account of the heavy traffic centering in and around these cities.

After this, successive sections will be equipped working eastwardly at such a rate that by 1928, the whole line will be under electric operation from Akashi to Numadzu. By 1928, the Atami tunnel will be completed and the electric equipment of the Tokaido line can be completed by joining Numadzu to Odawara through the Atami cutoff. At the present time there are about 600 steam locomotives assigned to this line and to replace this steam equipment, electric locomotives will be purchased on successive years in order to fill approximately the following schedule:

1923	28	electric locomotives
1924	38	" "
1925	48	" "
1926	76	" "
1927	73	" "
1928	73	" "
Total	336	

Of this total number, 42 locomotives have already been contracted for and in part delivered. Purchase of additional locomotives will, however, be delayed until sometime in 1925.

Construction Features

Referring now to trolley and overhead construction, a very substantial type has been selected and is being installed. The standard type of overhead construction consists of steel poles either latticed or tubular with a light bridge supporting the catenary. Where wood poles have been installed, it is admittedly only for temporary use and is installed on account of the expected relocation of tracks or other similar changes. The Japanese engineers have adopted throughout for both transmission and distribution lines the best types of construction and the work of their track and line men has resulted in a very handsome and permanent structure.

As to the extent to which railway electrification will be finally adopted, it is impossible to say at the present time. The committee for investigating this subject has already designated 2000 miles of railroad as suitable for electrification, selecting particularly those sections where heavy grades or tunnels, heavy suburban traffic, available electric power, or other conditions make steam operation difficult or emphasize the advantages of electrification. There is now under construction in Tokyo a short piece of elevated road connecting the main Tokyo station with Ueno station on the Tohoku line. When this is completed there will be direct physical connection between the Tokaido and Tohoku lines and through trains can be dispatched through the city of Tokyo from one line to the other. This will require a main central station in Tokyo from which all trains can be dispatched over both lines and will eliminate the delays now incident to transferring from one station to the other.

While it is improbable that the Imperial Government Railways will be justified in electrifying all the lines of its system, it is very probable that within a reasonably few years, we will see main lines electrified on such a general and consistent scale that the system will present an example of the advantages of railway electrification that will well repay the study of the railway engineer.

The Japanese telephone authorities hope to complete installation of telephones in 30,000 houses by next summer.

A Mechanical Coaling Plant at Stratford on the Great Eastern, England

Economies in Selection of Motor Bearings

Experience Teaches That No One Type Is Suitable for Use in All Kinds of Service

By Alfred C. Turtle
Shop Electrical Engineer, Canadian National Rys.

MUCH controversy has taken place on the question of the superiority of bronze oil bearings over ball bearings and vice versa. The arguments advanced in favor of the latter have generally been on their remarkable efficiency and peculiar adaptability to machines constructed with small air gap clearances, as well as freedom from seizing the shaft when subject to the abuses of tight belts and overloads.

The arguments in favor of the bronze or babbitt oil ring bearings have chiefly been their inexpensive first and replacement cost—surely a sound argument—their cost of repair and their maintenance with moderately experienced supervision.

After all, service is the prime requisite of any apparatus

Fig. 1—Shelves Arranged for the Convenient Storing of Motor Bearings

and in order to have dependable and quick service it is necessary to have a stock of all sizes of bearings on hand to suit each particular make and size of motor. With ball bearings the value of such stocks would amount to considerable sums especially where the maintenance of 300 to 400 motors of the varied sizes is considered. In a railroad shop the sizes range anywhere from 500 down to 1/10 h.p. and generally include a goodly selection from all the leading manufacturers. With standard brass bearings made from generous patterns that allow machining to a number of motor sizes without the necessity of cutting too much metal away, the comparison of first and maintenance cost of the latter bearing to the ball bearing is like comparing cents to dollars. In addition, the tie up of capital in store stocks is further a big consideration. Brass or babbitt is a reclaimable material, easily obtained without complicated advice as to shaft and housing fits, whereas ball bearings are opposite to these requirements.

The writer's experience with oil ring bronze or babbitt bearings has been, with certain exceptions, extremely favorable towards the same when considering their application to average conditions of service on electrical apparatus in and around the majority of railroad repair shops.

There are a number of exceptions to this, however, where ball bearings are particularly suitable, for instance, in crane service where comparatively slow running variable speed constantly reversing service is required of motors.

Ball bearings seem particularly suited to this work in that no peculiar condition of loading and operation can cause the shaft to seize.

This bearing is similarly suitable in locations where extremes in weather conditions rule, in locations of a dusty nature, and of isolated units that are not within reasonable distance of service departments. Isolated automatic pumping stations, coaling docks along the right-of-way, etc., may be cited as examples.

A consideration of the advantages of each type of bearing discloses its peculiar adaptability to different services, but such advantages should not be confused. For example, the use of ball bearings as mentioned would give the impression that service would be an outstanding point when using these bearings and that considerable saving of supervision could be avoided by their use. To this the answer comes that all electrical apparatus in any industrial plant should be subject to a reasonable amount of inspection. Such apparatus should be fairly used and not abused by operatives; it should not be overloaded seriously; dirt, sawdust, wood, steel or brass cuttings should be kept away, and water, cutting fluids, oils, extreme temperatures, such as proximity to portable oil furnaces or sparks from adjacent acetylene or electric welding operations should be guarded against. Such conditions cannot be guarded against permanently on account of the rapidly changing location of machines, re-arranging of units that constantly goes on in the never ending desire to better and cheapen production. In addition the checking of air gap, changing loads, cleaning and painting of windings and other adjustments to commutators, brushes, brush gear, etc., an absolute check up is and must be periodically practiced. Therefore an oiling schedule becomes part and parcel of such an inspection system and automatically gives you a closer examination of each unit which can be capitalized on, if the mechanic doing the oiling is intelligently assigned to his duties. An inspection other than this may become inefficient where units are inconveniently situated or where awkward or unpleasant conditions surround such units.

It is therefore seen by the foregoing that routine inspection is necessary on all electrical apparatus around railroad shops, and if ball and roller bearings are in use that particular attention is paid to even these units. For instance grinding noises, or undue vibrations, can be caused by pitted or broken balls, or rollers. Worn retaining cages may be due to electrolysis, the presence of grit, the use of inferior grease, or of not enough lubrication.

Requirement of Oil Ring Motor Bearings

A standardized system of handling oil ring motor bearings can be very simply applied by carefully taking sketches of the different motor bearing dimensions as the motors come in for repairs, or from sample of old or new bearings in store stock.

From these sketches, patterns can be made up and records of same carefully kept in the electrical department office in addition to the usual pattern and drawing office record.

The stores department should be notified as to what

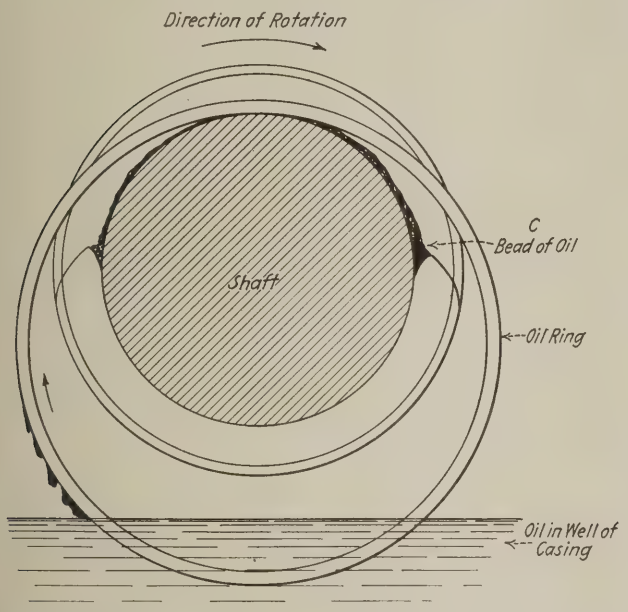


Fig. 2—Showing the Action of Oil Ring In Bringing Oil to Surface of Shaft and Forming Bead of Oil—This Also Illustrates the Importance of Running Ample Oil Groove From the Nearest Point of Bead of Oil.

castings in bearing brass will be required and should in the usual course from then on keep a regular stock of such castings.

The machining and fitting of these and all motor bearings should be in the hands of the electrical department millwrights and reports forwarded from them as to quality of brass being received from time to time. They will in turn, due to their familiarity with the apparatus, have dimensions as to the variation of motor shaft sizes from standard. There should be few serious variations from standard sizes, but to a certain extent such variations are unavoidable when service is the first consideration. Motor shafts may have become scored due to seizing, or worn unevenly in ordinary service and a light trim in the lathe may have been necessary to restore such bearing surfaces to a working condition. It is, therefore, practical to keep a stock of partly and fully machined bearings in a suitable rack which can be provided for that purpose, and which should be suitably lettered so that bearings will be easily and quickly picked out for emergency and ordinary repairs, etc.

Fig. 1 shows a single design of rack particularly suited to the storing and indexing of bearings for shop motors.

Oiling Considerations

Oil grooves and rings require a certain amount of special mention here and should receive careful consideration. In fact the neglect of this particular feature will ruin what otherwise may be the best of bearings. This is a very simple matter and can be taken care of quite easily. I have found that oil grooves applied as shown in the Figs. 2 and 4 will practically cover the requirements of any motor service whether drive be vertical or horizontal. The groove should be clean cut so that the oil can readily flow. With the brass cast bearings the groove can be cored in. In such case particular care should be taken to clean the groove with a sharp tool, of all sand, etc., that may be left in.

It is important to note that the rings fit loosely on shaft and that they revolve freely on the upper surface of shaft only clear of points *A* and *B*, and at the same time have their bottom surfaces fully immersed in the oil. It should also be noted that the oil ring slot is cut so that the point *C* has a tendency to hold a large bead of oil and redirect it into the oil grooves.

Vertical guide bearings on pump motors are generally babbitt or brass while the weight of motors is generally taken care of with a thrust ball bearing. The guide bearings are usually the chief source of trouble in this type of apparatus. When first set up a perfect bearing fit can be made and for a long period good results may obtain, but due to the fact of changes in the running center caused by slight changes in foundation settings, vibration, unequal wear of pump runners, etc., it is generally found that the shaft will appear to bear in one section of the bearing only and as the movement of the oil is down-

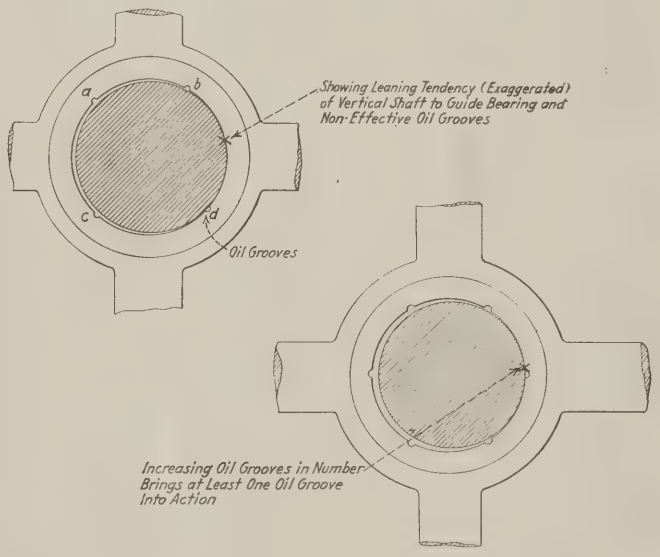

a
b
c
d
Showing Leaning Tendency (Exaggerated) of Vertical Shaft to Guide Bearing and Non-Effective Oil Grooves
Oil Grooves
Increasing Oil Grooves in Number Brings at Least One Oil Groove Into Action

Fig. 3—Plan of Guide Bearing

wards it is sometimes quite a problem to ensure proper lubrication of the bearing surfaces.

Fig. 3 illustrates a plan section of a motor shaft on such an application, and it is shown as in the case of a partially worn bearing (exaggerated). If four oil grooves running vertically or parallel with the shaft are applied at points *a, b, c, d,* it would be apparent that practically no oil would reach the shaft, if it leaned against the bearing as shown. Some method must therefore be used in which oil can reach the shaft and be pulled around in between the shaft and bearing thus forming the lubricating film. In view of the fact that that illusive perfect balance does seldom exist and that nearly all motors of the vertical type seem to have a leaning side it is necessary to make allowances for the above condition even in

new motors either by using an extremely heavy flow of oil to ensure a film of oil between shaft and bearing, or putting in a sufficient number of oil grooves so that at least one will come in contact with the shaft.

Ball Bearings

Where ball bearings are applied to direct drives and in fact any form of drive, but more particularly the former, it is very necessary to note that much better results will be gotten if the inner race is arranged on an extended sleeve arrangement as shown in Fig. 5.

Such an arrangement will tend to distribute stresses over a wider area than would be the case in ordinary applications which would have a tendency to give trouble with broken shafts at point *B*, particularly where such applications were made on crane and gear driving service.

The observer would possibly be inclined to think that a direct solid coupling would cure this peculiarity. Such is not the case however, because structures such as cranes are all subject to bending stresses, and the vibration of the framework is always tending to disalign such couplings. The effect then becomes of an eccentric nature tending to produce alternate stresses on the shaft particularly next its most rigid points.

When fitting ball bearings to a motor it is necessary that the inner race be a tight fit. General practice requires that sleeve and inner race be tight on shaft and this is usually accomplished by having a shoulder turned on the shaft for sleeve or inner race to fit up to and to have a threaded portion of the shaft arranged so that a double lock nut can bind the whole solid with the shaft. In some cases no such provision is made and a pressure fit on shaft is only demanded. In this case the fit must be absolutely true and devoid of irregularities or punch marks, as any such imperfection would of course have a tendency to spring the inner race out of round. In any case the shaft should be as perfect a fit as possible.

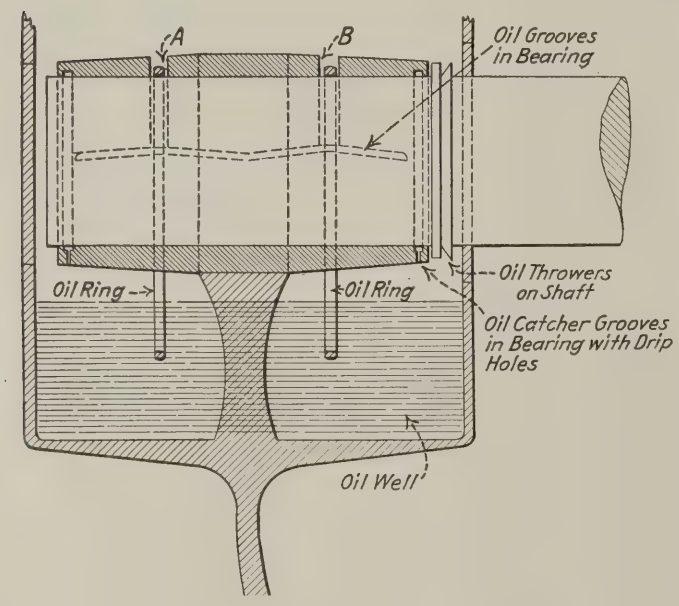


Fig. 4—Sectional View of Oil Ring Bearing

Annular ball bearings particularly require attention in the above detail, and where fitted to electric motors should be purchased in such a way that the manufacturer is fully cognizant of this, so that he will supply a bearing which is built with suitable clearance between balls and races to take up expansion due to heat traveling along the shaft from the rotor or armature.

Axial expansion must be allowed for as also the magnetic center and its slight realignments when the armature or rotor adjusts its flux condition with the load. This is taken care of by making the outer race a push fit into its housing and allowing proper clearance each side of the outer race and housing for the above characteristics.

The foregoing applications are reversed, of course, when applied for instance to a loose pulley, the outer race becoming the revolving element and therefore tight fitting unit, and the inner race becoming the element to take up alignment.

Where applications are made to trucks and where the load is concentrated at the top position of the ball or roller bearing, it is sometimes an advantage to take up the specific problem with the manufacturer and to make special arrangements to prevent peculiar action that goes with certain applications, *i.e.*, the tendency of the ball and rollers to resist climbing up and around the shaft or journal when under extreme load. A little thought on this matter will at once bring to the mind that on a bearing of this type each roller or ball in its rolling around must take up the maximum weight assigned to it as it approaches the top. Like many human beings it is reluctant to take up its alternate loadings and transfers its reluctance to the cage or rotating frame. Its reluctance to travel around is greatly increased as it and the races become worn. Therefore more than ordinary watchfulness is required to ensure service being continuous. In several applications, particularly railway service, it is to be noted that there has been a tendency to make the journal stationary and to fit a tubular journal over the stationary one in such a way as to cause the outer race to be the revolving member and the inner race the stationary member, thus producing the ideal condition which up to date seems to give the best results, *i.e.*, outer race revolving with the inner race stationary.

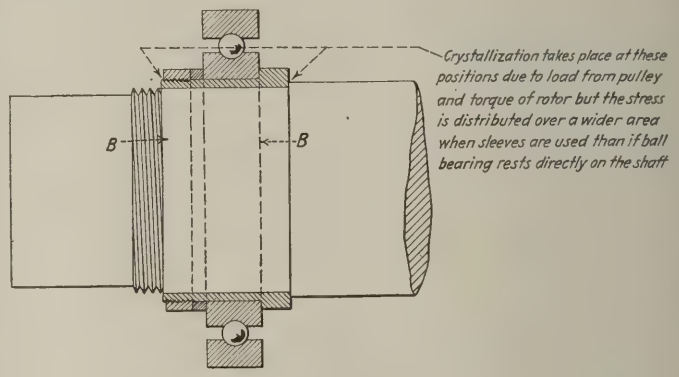

Crystallization takes place at these positions due to load from pulley and torque of rotor but the stress is distributed over a wider area when sleeves are used than if ball bearing rests directly on the shaft
B
B

Fig. 5—Showing Arrangement of Oversize Ball Bearing Used in Conjunction With Sleeve on Shaft for Electric Motor Application

It is interesting to note that grease for use on ball bearings must of necessity be chosen with extreme care. Freedom from graphite or any substance having any tendency to harden or coagulate is most important. In addition to this the lubricant should be non-freezing in winter and also not tend to become thin in hot weather. Greases having these qualities can be purchased and for the best of operation with ball bearings the use of such should be insisted on.

The more recent developments on flexible, inclined and double and solid types of roller bearings are also of material value in suiting certain conditions. For instance the flexible roller type is largely used where reciprocating or plunger action of driving members would tend to materially shorten the life of a solid roller bearing, but are generally suitable for moderate speeds only. There is no doubt that there is yet room for improvement in general design and for more suitable application of the different types of the so-called frictionless bearing to its respective positions, but at the present time the oil ring bearing has unquestioned qualities which are hard to beat and will necessarily tend to deter the rapid advancement of the other types of bearings in this particular field.

Railroads Ask Train Control Hearing

A PETITION asking the Interstate Commerce Commission to re-open the proceeding in which it has issued orders to 94 railroads to make installations of automatic train control, to the end that the time for compliance with its order directed to 49 carriers be extended for one year to January 1, 1926, that the later order directed to the same roads and 45 additional carriers be annulled; and that modifications be made in the original order, was filed with the commission on March 3 by a committee of railway executives representing the Eastern, Southern and Western carriers, respectively, and made public by the commission on the following day. The petition was signed, on behalf of 88 Class I roads, by Samuel Rea, president of the Pennsylvania; R. N. Begien, for W. J. Harahan, president of the Chesapeake & Ohio; N. D. Maher, president of the Norfolk & Western; W. L. Mapother, president of the Louisville & Nashville; Ralph Budd, president of the Great Northern, and L. W. Baldwin, president of the Missouri Pacific.

The four roads named in the commission's orders which did not sign the petition are the Chicago, Rock Island & Pacific, whose installation has already been approved by the commission, the Cincinnati, New Orleans & Texas-Pacific, the Mobile & Ohio and the Southern.

The railroads, in the petition, take the position that no train control device has yet been installed which can properly be said to be more than an experiment, that it cannot be ascertained in advance that any of the devices, with possibly one exception, will meet with the approval of the commission if installed, that very large expenditures would be involved in complying with the order without knowledge whether the installation would be approved by the commission when completed or whether the devices will function in such a way as to be a source of safety rather than a source of danger; and that the order of January 14, 1924, directed to additional roads and also directing additional installations by the roads named in the earlier order, was issued without notice or hearing.

In addition to the extension of time the roads ask that the order be amended to reduce excessive duplication of installations of the same device and by omitting the provision stipulating approval by the commission or its representatives of each installation when completed.

After citing the provisions of the law under which the commission issued its orders, and referring to the commission's order of January 10, 1922, addressed to the principal roads and directing them to show cause why an order for installation should not be issued; to the hearings which followed, and the order of June 22, 1922, addressed to 49 roads, the petition continues as follows:

Text of Petition

IV. That thereafter each of the carriers, parties to this petition, filed with the commission the signal plans, if any there were, of the divisions selected for such installations, statements of the number of locomotives in use upon such divisions, and prepared to carry out the other provisions of the order, in the selection of the device, or type of device, for use by each, and in such experimentation and study as would enable each of such carriers to make such a selection as would comply with the provisions of the order and as would be best suited to the needs and conditions of each carrier. That a very large number of automatic train control devices, or alleged automatic train control devices, have been invented; that a large number have been actually tested by small installations upon the lines of different carriers, both before and since June 22, 1922, the date of said order, but that no train control device has yet been installed, either upon a large or a small scale, which can properly be said to be more than an experiment; that the differences in design of the many devices which have been invented or tested, with the fact that none of such devices is interchangeable with any other; that it cannot be ascertained that, in the opinion of the commission, any of such devices, with possibly one exception, will meet with the approval of the commission if installed, and that delays and difficulties in the delivery of materials have occurred and will occur, have caused unavoidable delays in the compliance with the terms of said order; so that, although many contracts have been made for such installations, other contracts are on the point of being made, and installations, in many cases, are actually in course of being made, many installations, that are now being made, or that will be made, will not be completed by January 1, 1925; that very large expenditures, amounting to many millions of dollars, have been made or will be made upon such installations, and that it is uncertain whether, when such installations have been completed, they will be approved by the commission as complying with its specification either in design or in installation, or whether any of such devices will fulfill the purpose for which they are intended, or, in regular and daily operation, function in such a way as to be a source of safety rather than a source of danger.

V. That the installation of train control, as directed by the said order of June 22, 1922, will involve the carriers named in said order in the expenditure of many millions of dollars, the exact amount whereof cannot with accuracy be ascertained, adding largely to the expenditures upon road and equipment from which no return will be received and adding largely to the maintenance costs of each of said carriers whereby operating costs will be increased and the rate of the net returns to such carriers will be proportionately decreased.

VI. That on the 14th of January, 1924, the commission made a further order, such order containing specifications and directions as to reports of progress and as to approval by the commission. . . .

VII. That, as above set forth, no full installations, with possibly one exception, have been made under the order of June 22, 1922, and it is not known, and will not be known for a long period of time, what the result of the operation of train control devices upon an extensive scale will be. It is not known, and will not be known, until the completion of the several installations for which contracts have been made, or are about to be made, whether such installations will or will not be approved by the commission, or whether the devices, or types of devices, selected and installed, will be approved by the commission or its representatives as meeting the specifications contained in said orders. That compliance with the said order of January 14, 1924, will involve those carriers named in the order of June 22, 1922, who are parties hereto, in the expenditure of many millions of dollars, with no return; that said expenditure will add largely to the investment in the property of each said carriers used in the service of transportation and that no return will be received upon such additional investment, but that the addition to the investment in its property will have the effect of decreasing the return now received, and, in addition thereto, the cost of maintenance of said installations will be very great, and that as no revenue will be received on account of such investment the only way in which such decrease can be made up is by an increase in the passenger rates, or the freight rates, or both, of the

several carriers, and that no provision has as yet been made for such increase, or for determining what the percentage of such increase shall be; and that said expenditure will result in no assurance of the securing of additional safety in the operation of the railroads of such carriers, but will involve the possibility of added danger to such operation of the railroads by reason of the installation and operation of such devices.

VIII. That the additional carriers named in the commission's order of January 14, 1924, had no notice of this proceeding, no notice of the intention of the commission to make said order, and that said order was made without a hearing, either of the carriers parties to the order of January 10, 1922, or of the additional carriers.

That many of such last-named carriers are carriers with small traffic, with small net revenues, or no net revenues, with infrequent trains, both freight and passenger, and with no installations of automatic signals. That upon such lines no necessity exists for the installation of automatic signals, or of automatic train control, for the reason that traffic upon such lines is so light that no additional safety in the operation thereof would be attained by the installation of either. That the expense to many of such lines of the installation of train control, even upon a single division, is so great in proportion to their revenues, either gross or net, if there be any net, as to bring such roads perilously near bankruptcy, and that upon many of such roads the need is not for the installation of train control, but for capital to make needed improvements.

That the requirement for the installation of train control and for approval of such installation by the commission, after completion thereof, deprives the carriers named and each of them of the power of deciding whether such installation should be made, where such installation should be made, and how such installation should be made in such a way as to suit the needs of each particular carrier.

WHEREFORE, your petitioners pray:

I. That this proceeding be reopened, and a rehearing granted before the full commission, to the end that the order of June 22, 1922, be amended by

1. Extending the time for compliance therewith to January 1, 1926.

2. Reducing excessive duplication of installations of the same device at great capital expense until further experience and experimentation has solved the question of interchangeability and effect on capacity for moving traffic, as well as the further development of the appliances from the present experimental stage.

3. Striking out from said order the provisions for approval, by the commission or its representatives, of each installation when completed.

And your petitioners further pray:

4. For a reopening of this proceeding and for a rehearing before the full commission respecting the order of January 14, 1924, to the end that the said order may be annulled.

Improvement of Machine for Digging Holes and Setting Poles

THE Four Wheel Drive Auto Company, Clintonville, Wis., has secured from the International Earth Boring Machine Company of Chicago the exclusive rights to manufacture and sell the earth boring machine. The machine has been redesigned, built and is now sold as FWD equipment.

The FWD earth boring machine is a machine that digs the holes and sets the poles in them as well. The special advantage claimed for the FWD earth boring machine combination is the equal distribution of load and power to the four wheels of the truck. This principle of power transmission allows for the great amount of traction that is necessary to negotiate the bad roads, ditches and fields. The short turning radius of the truck (25 ft. 3 in.) permits the machine to go in and out of the tight places.

After the truck has been spotted, the emergency brake set and the wheels properly chucked, the power is applied to the earth boring machine by shifting the central control lever out of neutral and into a position which engages the earth boring machine power take-off with the transmission.

The auger is lowered and slowly fed into the ground by gradually lowering the auger with slight jerks on the auger feed clutch lever. When the auger is buried into the ground, the auger drive clutch lever is pushed in and the auger is raised above the ground by pushing the auger feed clutch lever. The driver is then given the signal for third or high speed with full acceleration of the engine. This releases the auger of the dirt which

Machine Located for Operation
Digging the Hole Setting the Pole

has accumulated. This operation is continued until the auger shaft has traveled its limit or until the hole has been dug the required depth.

The cable is fastened to the pole at as near a balancing point as possible. After the hole has been dug, the chuck blocks are removed from the rear wheels and the truck driven forward until the winch boom is even with the side of the hole. The signal is then given the driver for first speed and the pole is slowly pulled toward the digger and up toward the boom. If there are wires above, the pole must be in parallel line with the wires. The pole is then pulled up slowly, with a man at the butt to guide it through the wires and bring it over the hole. When the bottom of the pole is clear of the ground the driver is given a signal to stop and apply the brake. Then, with slow acceleration of the engine, the pole is lowered into the hole.

The National Administrative Council of Uruguay has completed its studies for utilizing the water of the Rio Negro for generating electric power for the City of Montevideo and surrounding towns. The contract for the erection of the plant will be awarded shortly.

Emergency Control for Shop Motor Drive

The necessity for stopping all of the machinery in the shop very quickly may not occur often, but when the emergency does arise, it is well to be ready to meet it. In shops where individual motors are used on machine tools, each tool is equipped with a stop and start push button, but in many shops where belt drives are commonly used and where many machines are operated from a single motor, it is quite usual for relatively few, if any, stop buttons to be used. The result is that in the event of an accident, such as a workman being caught in one of the machines, the stop button may not be located near enough to stop the machine in the least possible time.

In order to overcome this condition in a shop where many machines are operated, an ingenious system, utilizing the principles of air brake operation, was installed. The idea is presented in the sketch, although, some of the details are different in the actual installation which is in the Erie Railroad machine shop at Jersey City.

It will be seen that a compressed air supply at, say 125 lb., is fed through a reducing valve to any desired pressure in a piping system that is similar to that used in the operation of air brakes on trains. The system of pipes supplies air to triple valves and auxiliary reservoirs which store up the necessary reserve pressure for the operation of the brake cylinders.

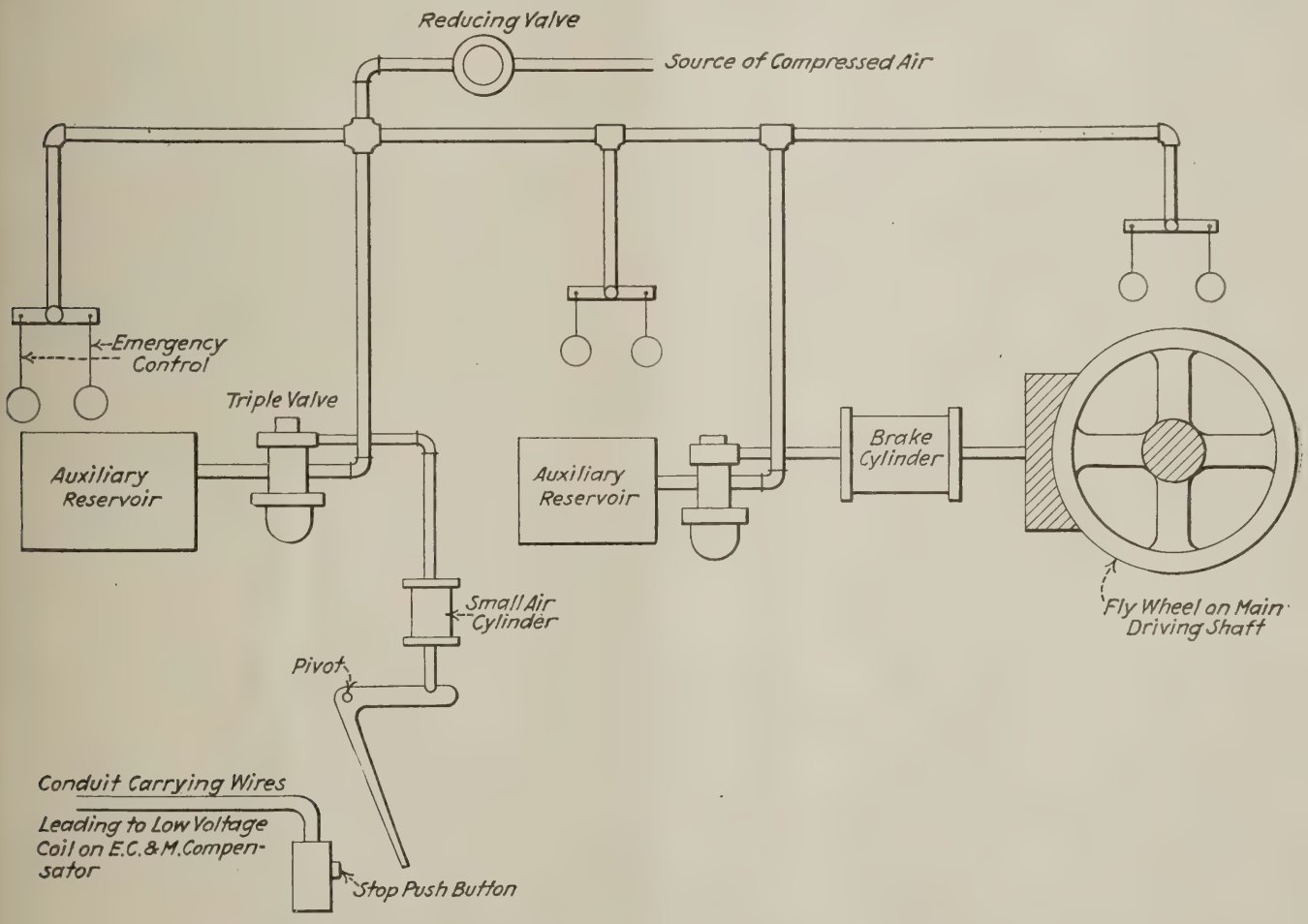
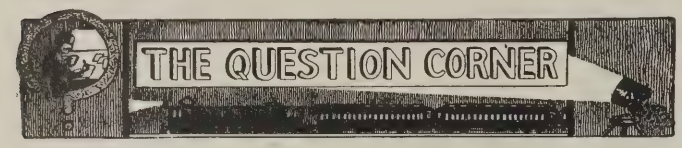


Diagram of Piping and Arrangement of Apparatus Used in Emergency Stop Equipment

In order to see just how this arrangement works out, it may be well to follow through a sequence of operations. Assuming that it is desired to stop the motor suddenly, someone pulls down on one of the control rings which are located at frequent intervals throughout the shop. These

emergency controls are connected by means of short heavy wires to a T-shaped valve at the end of an extension of the low pressure air pipe line. The moment one of these rings is pulled, the air in the low pressure line escapes and the reduction of pressure immediately operates the triple valves. With the operation of these valves, air in the auxiliary reservoir rushes into the brake cylinders. In the case of a small cylinder, the piston rod is pushed downward thereby causing the bell crank attached to it to strike the push button, and this in turn causes the motor to stop through the operation of the low voltage release coil. At the same moment the other triple valve has operated and air from its auxiliary reservoir is applied to the brake on the large fly-wheel which is mounted on the main belt shaft. The cutting off of the power at the motor and the application of the brake at the same instant make it possible to stop all of the machines in the shop almost instantaneously.



Answers to Questions

1. *In an axle lighting equipment, why is it that, when a dynamo is out of level compared to the car axle to which the axle pulley is attached, that when the car is moving in one direction the belt will run to one side of the dynamo pulley, but when the car is moving in the opposite direction the belt will run to the other side of the dynamo pulley?*

2. *I would like to have you explain also why it is that when a pulley is crowned, the belt will stay in the center of the pulley running to the high point, but when the shaft of the dynamo is not parallel with the car axle, the belt will run to the low side, or the side nearest the car axle.*

Axle Generator Alignment

1. One of the commonest laws of the operation of belts is that they run to the high side, so that in a crowned pulley, if the belt is off center it will run up on the crown until the center of the belt comes over the center of the crown, at which point the tendency of one-half of the belt to run to the high side will be balanced by the tendency of the other half of the belt acting the same way in the opposite direction.

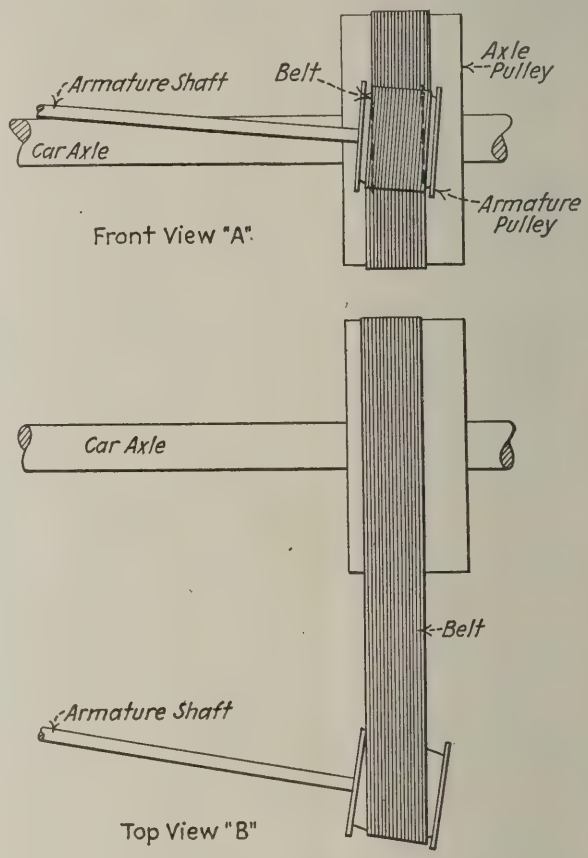
It is a well known fact, however, that in many cases where very wide belts, in proportion to their length, are employed, they do not seem to follow this rule. This is probably due to diagonal stresses within the belt which may draw it to one side or the other.

The diagram *A* shows a front view of the axle pulley and generator pulley, with the generator shaft badly out of level. If the belt is traveling so that it passes downward over the face of the generator pulley it will be carried to the left slightly, as it passes over the generator pulley, because of the fact that the armature shaft is tilted. The amount of this shift over to the left is indicated by the difference between the dotted line and the belt edge as it leaves the pulley.

This will cause the belt to creep to the left until that tendency is overcome by the reverse tendency to ride the crown of the pulley, or until the belt rubs against the flange of the generator pulley.

If the direction of the car reverses so that the belt passes upward over the face of the armature pulley, the action will be just the reverse. Any point on the belt as it revolves with the armature pulley will be carried slightly to the right and the tendency will be for the belt to creep to the right until this tendency is overcome by the tendency to ride the pulley crown or until the belt rubs against the flange. If the generator is tilted in the opposite direction, the belt shift will, of course, be just the opposite.

2. Diagram *B* applies to question 2. In both of these diagrams, however, the armature shaft is shown badly out of line, so as to explain the action more clearly. Accord-



Sketches Showing Action of Belts When Car Axle and Generator Shaft Are Not Parallel.

ing to the way a belt acts on a crowned pulley, we would expect this belt to crowd the outer flange of the pulley, which is the high side, or that farthest away from the center of the car axle. We find by practical experience, however, that this belt actually goes to the low side. This is contrary to the usual experience with belts, but is probably due to the fact that the car lighting belt is rather wide and heavy and of comparatively short distances between pulley centers, so that diagonal stresses are set up within the belt which draw it to the low side.

Questions for March

1. *I am anxious to secure a little information that will help me in the design of a spot welding transformer. What voltage and current does it take to spot weld two pieces of jacket iron together, the iron being 1/16 in. thick? The transformer I want must operate on a 220-volts, 60-cycle power line. What size copper will I need on primary and secondary and how many turns on each? What size core will I need?* C. M. G.

2. *Can you illustrate the law showing the relation between transmission line loss and voltage?* E. C.

NEW DEVICES

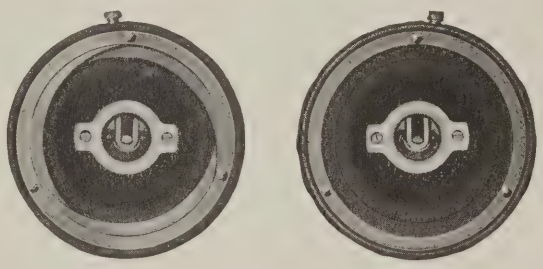
Enclosed Lighting Unit with Safety Holder

A direct lighting totally enclosed lighting unit known as the 99 safety unit has been developed by the Western Electric Company. In appearance it is similar to the No. 99 enclosing unit manufactured by this company but is different in that a new type of holder is used.

Inside of the holder are internal contracting rings which can be made to close in on the neck of the globe. Moving the knurled nut on the side of the holder in one direction expands the concentric rings so the bowl can be inserted. Moving the same nut in the opposite direction contracts the rings to hold the neck of the globe. A turn of the nut locks the rings securely in place so the bowl cannot fall out. In this way the globe is centered automatically and an even pressure on the neck of the globe is secured.

Western Electric 99 S H Safety Type Hanging Unit With Plain Glass Globe

The holder is finished in dark statuary bronze. Ample room has been provided for wiring and the holder forms a dust-proof housing. The canopy has one knock out for canopy switch installation. The globe is designed to give a maximum of strength with a minimum absorption of light and the surface is sufficient to carry off the heat without openings for ventilation. The principal advantages claimed for the unit are that re-lamping and cleaning are made easier and that there is less likelihood of the bowl being broken when removing and replacing it in the holder.



Open End of Holder Into Which Globe Is Inserted Showing Expanding Rings in Open and Closed Positions

1500-Watt Turbine-Generator

A steam turbine-generator lighting set with a rating of 1½-kw. has been developed by the Westinghouse Electric & Manufacturing Company for use on steam shovels, oil well rigs, isolated pumping plants and general outdoor construction work.

The machine is simple and rugged, the generator coils being especially impregnated and the parts needing such protection being Sherardized. There are but five castings used in the construction of the machine and only five moving parts. The moving parts are the shaft carrying the generator armature and turbine rotor, two governor weights, the governor spindle and the valve stem. The outfit requires no bed plate or foundation. The turbine and generator ends of the unit are completely isolated to insure against the possibility of short-circuiting of windings due to steam or water entering the generator end.

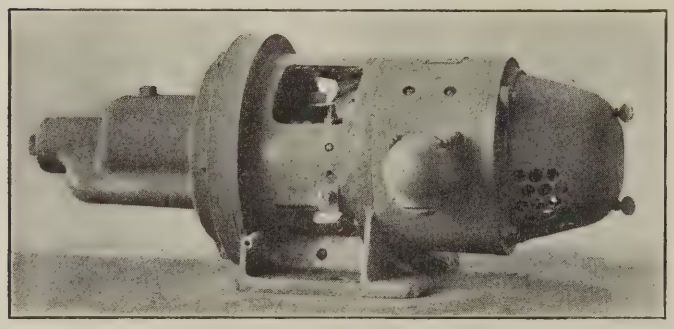
The turbine rotor is of a distinctive design in that it is a solid forging in which the buckets are milled on the

inside periphery of an overhanging flange. The turbine disc in itself provides for accidental overspeeding. When the speed exceeds a predetermined limit, the rotor flange of the turbine expands and fills the clearance space in the cylinder. This establishes a rubbing contact which acts as a brake and restrains the speed within a safe limit.

The steam nozzle and reversing chamber are die cast in a single block of bronze alloy, which is bolted to the inside of the turbine cylinder. The steam, expanding in the nozzle, acquires velocity and impinges on the rotor bucket, thus giving the rotor an impulse in the desired direction. Part of the velocity of the steam is absorbed in this way. It passes from the bucket to the reversing chamber, where its direction is reversed and where it is re-directed on the bucket. The steam then passes from the bucket to the exhaust.

The speed of the unit is regulated by a fly-ball, centrifugal, shaft type governor which is carried in a heavy case bolted directly to the rotor disc. This governor is equipped with hardened steel knife edges and blocks and acts directly on the valve stem. Escape of steam around the rotor shaft is prevented by a gland of the labyrinth type employing metal sealing rings.

The generator consists of a forged steel frame ring, two



Lighting Unit for Isolated Pumping Plants and Outdoor Construction Work

cast iron brackets and the usual internal construction as to field armature and brush rigging. The field windings of the generator have the shunt and series winding wound in together as one coil, but inside the coil itself, the two windings are entirely separate and insulated from each other. The commutator end is provided with a protective, drip-proof, pressed steel cover which is held in place by two wing screws. A ventilating fan is mounted on the shaft outside of the rear bearing between the turbine and generator. The air is drawn in through the front cover, then through the generator and out of a number of openings in the rear bracket. This fan is guarded to prevent injury to the fan or the operator of the machine.

The armature laminations are pressed on a knurled portion of the shaft. The commutator is of the steel V-ring type with the V-ring held under pressure by means of a nut. The armature windings are wound directly into partially closed slots.

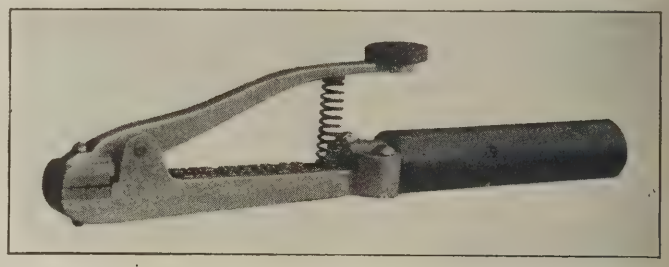
The bearings which are located in the generator brackets are equipped with oil wells of large capacity. The leads are brought out to a terminal block on the side of the generator and the terminals are protected by a cast iron cover which can be removed without disturbing the connections or conduit. A special fixture is provided for attaching the conduit.

The unit complete is 32⅝ in. long, 14⅛ in. wide, 12⅝ in. high and weighs 250 lb.

Welding Electrode Holder

A new lightweight electrode holder for electric arc welding has been placed on the market by the Gibb Instrument Company, Bay City, Michigan. The device is made of aluminum with renewable copper jaws and a ventilated fibre handle. The thumb piece is also fibre. The manner in which the electrode is held in the holder is apparent from the illustration.

The jaws of electrode holders are frequently burned by

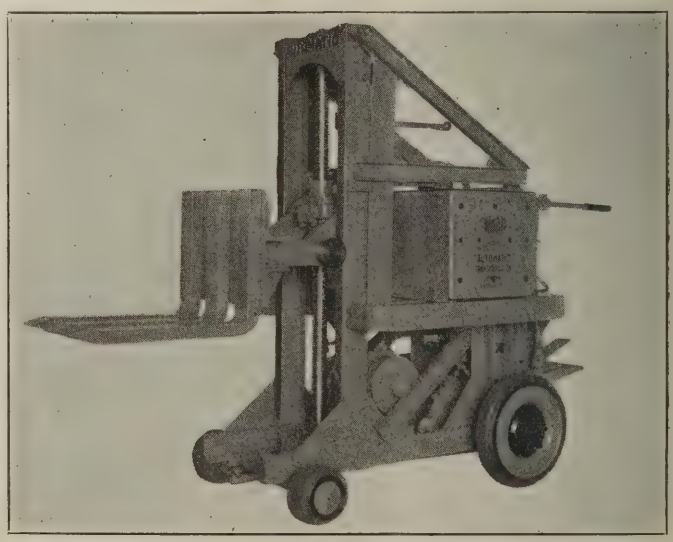


Welding Electrode Holder With Renewable Jaws and Special Cable Clamp

an accidental slip or by the operator attempting to use up all of the electrode and the jaws of this holder are made renewable to provide for this contingency. The cable connection with the holder is made by the clamp between the handle and the small spiral spring. It is placed at this position rather than inside of the handle to obviate the possibility of a hot handle caused by a loose connection. The weight of the holder complete is 15 ounces.

Automatic Fork Truck

One of the latest developments in the application of electric haulage units to interplant transportation is the fork truck now being manufactured by the Automatic Transportation Company, Buffalo, N. Y. This new type of truck has a number of advantages over previous lift trucks manufactured by this company. It can lift from



Forks Can Be Pushed Under Material Without the Aid of Skids

the floor barrels, boxes, bundles of metal sheets, plates, castings, etc., without the aid of skids. This eliminates a big investment in skid equipment and also conserves floor space.

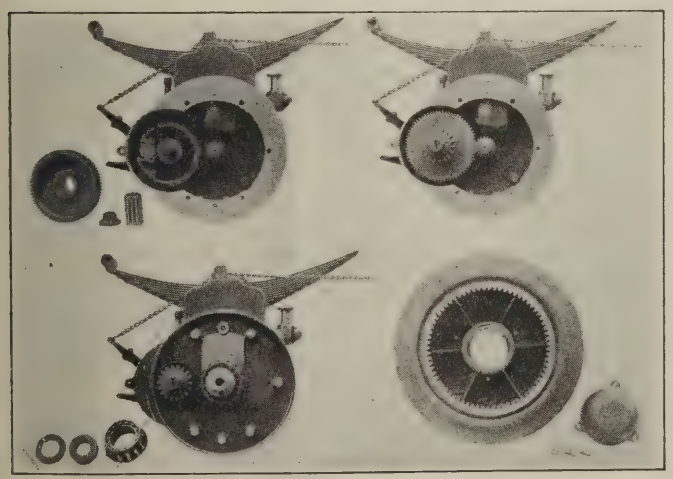
The principle of its operation is that the tapered steel

forks are designed to slide under the material to be carried, without any kind of assistance. Almost any type of material can be handled by this machine, the only requirement being that the width and length of the forks conform to the width and length of the material to be handled and for this reason the forks are furnished in various sizes to suit the character of the work in the shop where the truck is to be used.

The truck has a lifting capacity of between 3,000 lb. and 4,000 lb., depending on the nature of the material handled, and is built for various lifting heights. In any of the trucks, however, the loads can be started and stopped at any height. The truck is equipped with two motors, one for propelling the truck and the other for elevating. Both motors draw power from the truck battery. The lift is by means of a single oversize screw revolving in a large oversize bronze nut, which is provided with an oil magazine for lubricating the screw. The elevating mechanism is placed below the battery box to afford the best possible protection. The front wheels of the truck have 9-in. by 5-in. rubber tires, and are fitted with Timken bearings to give the greatest mobility with the least friction. This is an important factor to be considered as the entire load is carried over the front wheels. This truck is designed to meet the many demands around a railroad shop for moving and placing heavy castings on machines and for carrying and lifting heavy or bulky material in store houses.

Four Wheel Drive Lift Truck

A lift truck that has all four wheels individually driven by a standard vehicle motor has been placed on the market by the Terminal Engineering Company, New York. As shown in the illustration, the truck is equipped with four wheels of the same diameter, instead of the small diameter pilot or trailer wheels that are commonly used. It is claimed that the elimination of these small wheels



Detail Construction of the Rear Wheel Unit

permits greater freedom of action in traversing obstructions, such as crossing cobbled streets and railroad crossings. It is also claimed that the absence of the pilot or trailer structure permits the truck to approach closer to a box car in order to lift material from the floor of the car through the doorway. This truck has also proved to be of value for stacking material in warehouses.

The truck is built with varying heights of uprights to suit different requirements. The table, as shown in the illustration, can drop to a surface height of 5 in. from the floor. It is 4 ft. long by 26 in. wide. Provision has been made for changing the style of the table, which is easily accomplished by dropping out the old table and replacing in the uprights some other type, such as the horn, double tang, or V-type table. The horn type table is intended for handling coiled rod or reels, car wheels, etc. The double tang type, the top of which goes down to within 2 in. of the floor, is designed for handling such material as tin plate and for stacking. Other types of tables are available for any variety of work. The capacity on separable bodies for an evenly distributed load is as follows: 2,100 lb. on a 6-ft. platform; 2,300 lb. on a 5-ft.

Lift Truck Removing Boxes from the Door of a Storehouse

platform; 2.600 lb. on a 4-ft. platform, and 3,000 lb. on a 3-ft. platform.

The hoist can raise a 3,000 lb. load at a rate of 25 ft. per min. and it can elevate empty at a rate of 50 ft. per min. The hoisting unit is operated by an enclosed watertight motor of the same type as those used in driving the truck. The reduction is through a worm and gear, the worm and shaft being integral. A solenoid is used to release the brake on the motor shaft and an automatic brake is provided to prevent the load from being lowered too rapidly.

It is claimed that this truck can operate effectively in snow and ice conditions, and needs no specially prepared runways. It is carried on four wheels that have 20-in. by 5-in. solid rubber tires 3 in. thick. All four wheels are individually driven, each being provided with a standard vehicle motor, fully enclosed and weatherproof. There are three revolving members in the driving unit, consisting of motor shaft, integral reduction gear and pinion and the wheel itself. The entire unit is grease packed and requires practically no attention for long periods. The motor has ball bearings and in addition the reduction gear and the wheel rotate on roller bearings.

Steering is accomplished by the rear wheels. This gives the shortest possible turning radius of 6 ft. 9 in. The rear wheels are equipped with full leaf springs and are provided with internal expanding type brakes, actuating inside the reduction gear member. The brakes are controlled by the operator's foot. An odometer is provided on one wheel to record mileage.

The battery is placed over the rear wheels in a special compartment. Its location with respect to the load allows it to act as a counterbalance, the front wheels serving as the fulcrum. It also provides a seat for the driver.

General News Section

The Parkard Electric Company, Warren, Ohio, began operations on March 1 in its new plant especially built for the manufacture of transformers. The old plant will be remodeled and given over entirely to the manufacture of Packard automotive cables.

The Interstate Commerce Commission has granted the petition of the Illinois Central for a modification of its automatic train control order so as to permit an installation on the Illinois division, between Champaign, Ill., and Branch Junction, in lieu of the full passenger engine division prescribed in the order.

Six hundred thousand tons of rock was recently dynamited from a mountain near Lakeside, Utah, with one charge of 301,200 pounds of explosive. The rock will be used for ballast by the Southern Pacific. In placing the charge of explosive, 4,000 ft. of tunnels were drilled, the work requiring nearly six months.

The New York Central Railroad has recently placed an order for a 2,000 kw. motor generator set to be installed next summer in its automatic substation at 110th street, New York. This substation which has been operating about a year was installed for the purpose of increasing the voltage on the third rail during rush hours. When the new equipment has been added, it will be the largest remote control station of its kind in the United States.

The Electric Controller & Mfg. Co., Cleveland, Ohio, has announced a number of changes in its organization. Claiborne Pirtle, formerly president of the company was elected chairman of the board of directors. H. F. Stratton, who has been vice-president and chief engineer, was elected president. F. R. Fishback, who was sales manager, was elected vice-president and secretary. P. C. Clark, formerly secretary and treasurer, was elected vice-president and treasurer. R. G. Widdows, who has been manager of the New York office was appointed sales manager. D. C. Wright was appointed chief engineer. These men have been with the company for fourteen years or longer.

Radio was used by the Chicago & North Western in communicating with trains in northern Wisconsin recently, when a heavy snow storm cut off all wire communication. In several instances, reports from trains which were stalled in snow drifts were broadcast by local stations and relayed by wire to North Western officers by Chicago receiving stations. Messages for these trains from Chicago headquarters were then sent out by the Chicago radio stations. Radio reports were received from a Minneapolis, St. Paul & Sault Ste. Marie train at Waupaca, Wis., and from North Western trains at Reedsville, Waukesha, Sheboygan, Green Bay and Manitowoc.

Effective March 1. R. M. Kincaid, who has been works manager since August, 1920, for the U. S. Light & Heat Corporation, Niagara Falls, N. Y., manufacturers of USL storage batteries, arc welders and train lighting equipments, has resigned to accept a position with the Garford Motor Truck Company of Lima, Ohio. Mr Kincaid has served the company faithfully and well for approximately four years, and is leaving with the best wishes of the directors and officers of the company and his associates. J. K. Gould will carry that part of Mr. Kincaid's work which had to do with the manufacture of storage batteries, his title being superintendent battery division. Otto Van Goeben will carry that part of Mr. Kincaid's work which had to do with the device and arc welder end of the business, his title being, superintendent device division.

Electrification Postponed in Japan

The Government Railways of Japan have been compelled by the earthquake of September to postpone the electrification of the Tokyo-Kobe trunk line and are storing away 30 electric locomotives from the United States and Europe which they have recently assembled at their shops at Oi and Omiya. Officers in the Electricity Bureau of the Department of Railways say that the electrification of the trunk line has been postponed but that it does not mean indefinite suspension. Work will be started next year, the date of completion only having been deferred one year.

Atlantic City Exhibit

A great number of applications for exhibit space at the Railway Supply Manufacturers' Association exhibit in Atlantic City during the meetings of the Mechanical Division, June 11-18, and the Purchases and Stores Division, June 16-18, have been received. The number of applications filed up to this time is about 50 in excess of the number of applications filed at a corresponding date in 1922. Applications have been received from 245 exhibitors, representing 82,925 sq. ft., out of a total of 100,234 sq. ft. available. Applications for exhibit space or information about the exhibit may be obtained from John D. Conway, secretary-treasurer, Railway Supply Manufacturers' Association, 1841 Oliver building, Pittsburgh, Pa.

Opening of C. N. R. Radio Broadcasting Station

Sir Henry Thornton, president of the Canadian National, spoke in Ottawa on February 27 to a large number of the people of Canada through the large radio broadcasting station just installed in this city by the C. N. R. "This year," said Sir Henry, in inaugurating the radio service, "I want $30,000,000 from the Canadian National Railways, and I believe if we all roll up our sleeves and put our backs into the work we shall get it. The returns for January are just in. We have net earnings of practically $500,000, as compared with a deficit last year of over $500,000. True, net earnings of half a million a month do not represent a very large sum, but there is this

significant feature about it, last month was the first January for a good many years that we showed any net at all."

"Our chief objectives," said Sir Henry in conclusion, "must be a constant and alert effort for the improvement of our service, eternal vigilance in securing traffic, a high degree of courtesy to the public from whom we derive our revenue, and loyalty and fidelity to the company and to the Dominion."

Super-Safety Switch Company Builds New Plant in Chicago

The inventors and manufacturers of the Super-Safety switch, which was placed on the market in the smaller sizes in 1922 have recently organized an incorporated company, constructed a factory and installed machinery for making dies and assembling the switches. The new organization is known as the Super Safety Electric Company of Chicago and the new plant is located on 104th street near Washington Heights station on the Rock Island Railroad.

The construction of the switch is such that the line fuses are a part of the switch and when the switch is in the "ON" position an insulated dead front is presented, while in the "OFF" position the fuses and contacts are lifted out of connection with any live part thus in either position security against personal contact with live members is obtained. The manufacturers are now proceeding with the construction of dies to be used in manufacturing a full line of switches for industrial and railroad shop uses. The 440-volt switch as required extensively by the railroads is to be placed on the market in the near future.

New York Central Train Control Contracts Go to Three Companies

The New York Central Lines, on March 5, announced that contracts had been let for the materials for automatic train control apparatus on the five roads named in the Interstate Commerce Commission's first order, the work of installation to be done in all cases by the railroad companies. The roads involved are: (1) the Boston & Albany; (2) the Michigan Central; (3) the Cleveland, Cincinnati, Chicago & St. Louis; (4) the Pittsburgh & Lake Erie; (5) the New York Central. The contracts have been let for roads 1, 2 and 3 to the General Railway Signal Company; No. 4, the Union Switch & Signal Company; No. 5, the Sprague Safety Control & Signal Corporation. Each of the contractors is to begin work as soon as possible.

The sections of railroad covered are (1) Springfield, Mass., to Albany, N. Y.; (2) Detroit, Mich., to Jackson; (3) Indianapolis, Ind., to Mattoon, Ill.; (4) Pittsburgh, Pa., to Youngstown, Ohio; (5) Albany, N. Y., to Syracuse.

Proposed Electrification of C. N. R. Line

Another experiment in electrification is soon to be made by the Canadian National Railways in Ontario. It is planned to discard the steam service on the 30 miles of the former Canadian Northern line between Cobourg and Orono, the latter about 45 miles east of Toronto. When the Canadian Northern was taken over and consolidated with the Government system the former running from Toronto eastward closely paralleled the Grand Trunk and the Canadian Pacific and constituted a needless triplication of service. It is proposed to abandon entirely the 45 miles between Orono and Toronto and place electric cars on the 30 miles between that station and Cobourg. There will be a two-hour passenger service, and the rich farming and fruit community will be given an adequate freight service.

Roads to Protest Train Control Order

Following a conference in New York on February 15, a committee of six presidents was appointed to go before the Interstate Commerce Commission and show the unreasonableness of the recent order calling for the installation of automatic control apparatus on 94 railroads within two years. The committee consists of Samuel Rea, president of the Pennsylvania, and W. J. Harahan, president of the Chesapeake & Ohio, as representatives of the Eastern roads; Ralph Budd, president of the Great Northern and L. W. Baldwin, president of the Missouri Pacific, as representatives of the Western roads, and W. L. Mapother, president of the Louisville & Nashville, and N. D. Maher, president of the Norfolk & Western, as the representatives of the Southern district. The committee has full power to prepare its own case. It will ask the Interstate Commerce Commission for a conference.

United States Civil Service Examination

The United States Civil Service Commission announces the following open competitive examination for the position of electrician.

Receipt of applications will close April 1. The examination is to fill vacancies in the Departmental Service, at entrance salaries ranging from $1,000 to $1,200 a year, plus the increase of $20 a month granted by Congress, and vacancies in positions requiring similar qualifications.

The duties of this position require a knowledge of materials, operation, and especially maintenance and repair of electrical apparatus generally used as equipment of public buildings, including generators, switchboards, distribution of wiring motors, etc.

Competitors will not be required to report for examination at any place, but will be rated on their physical ability, and training and experience.

Full information and application blanks may be obtained from the United States Civil Service Commission, Washington, D. C., or the secretary of the board of U. S. civil service examiners at the post office or custom house in any city.

Privately Owned Railways Contemplated in Japan

In view of the heavy burden on the national treasury and its inability to put out capital liberally for the extension of the state railways the Department of Railways of Japan, which has been rumored for some time past to have departed from its traditional policy of nationalization, is giving charters to private capitalists and enterprisers for the construction of provincial lines. Recently Ichiji Yamanouchi, Minister of Railways, delivered a speech before a gathering of prefectural governors in regard to his construction policy. He said that the Government had decided to encourage private capital to invest in railways. Every help will be given to people who will build

important provincial lines, not only in the way of easy grant of charters, but in the way of subsidies. If the Government policy is actually carried out railways in Japan will again be favorite enterprises.

Personals

E. L. Lord, sales engineer of the San Francisco, Cal., branch of the Electric Storage Battery Company, Philadelphia, Pa., has been assigned to handle the railway sales for that office. He will also supervise the railway business for the Pacific district, which comprises six of the Pacific Coast states and part of Montana. Mr. Lord was born in Arcata, Cal., on March 4, 1884, and was graduated from the department of electrical engineering of the University of California in 1907. For three years he was engaged principally in power house and sub-station construction work. In May, 1910, he entered the employ of the Electric Storage Battery Company as assistant foreman and later served as foreman in its construction department. In the fall of 1912 he went to Los Angeles in connection with some special work and later became resident inspector in that city. In 1915 he returned to San Francisco as superintendent of the Exide depot, and later entered the operating department work as engineer of the San Francisco branch. In 1917, Mr. Lord began handling general sales in addition to his operating department duties. He will hereafter devote his time to the promotion of the company's railway business in the Pacific Coast territory with headquarters at San Francisco.

E. L. Lord

W. F. Frentel, foreman electrician on the Chesapeake & Ohio Ry. at Huntingdon, W. Va., was made supervisor of train lighting with headquarters at the same place. The position of supervisor of train lighting is a new one, the work having previously been handled by the chief electrician, which position has been discontinued.

J. W. Gibson, foreman electrician of the same road with headquarters at Newport News, Va., succeeds to the duties formerly performed by Mr. Frentel. There will be no change of title in Mr. Gibson's position but his headquarters will be at Huntingdon, W. Va.

Geo. L. Bebout, also foreman electrician on the C. & O. was transferred from Stevens, Ky., to Newport News, Va., with same title and duties. Mr. Bebout succeeds Mr. Gibson in a general change of foremen.

W. J. Connolly, formerly chief electrician on the C. & O., with headquarters at Covington, Ky., has been transferred to Stevens, Ky., with the title of foreman electrician, to succeed Mr. Bebout, the title of chief electrician having been discontinued.

Trade Publications

Kardon Products Company, 101 Varick St., New York, has just issued its new catalogue and guide book which features the more prominent radio wiring diagrams. A copy of the book may be had free upon application to the manufacturers.

The Griscom Russel Company, New York, has just issued its bulletin No. 1216, illustrating and describing the U-Fin cooler which it manufactures. The U-Fin air cooler is designed to be used for cooling air from generator windings by the use of turbine condensity.

The Martindale Electric Company, 11,727 Detroit Avenue, Cleveland, Ohio, has recently published a four-page, illustrated folder entitled, "Imperial Commutator Stones." The folder shows a number of new style handles and additional standard sizes and also gives a description of the Imperial grinding tool.

The Roller-Smith Company, New York, has recently issued its bulletin No. 210, illustrating and describing all of the direct current portable instruments except the small sizes which are illustrated in bulletin No. 110. Shunts, multipliers and leads for battery testing are also included as well as the price list of the instruments and accessories.

The Special Libraries Association of the United States, through a committee, is making a study of trade catalogs, and information is desired as to what firms keep an historical collection of trade catalogs. Information is desired by Lewis A. Armistead, chairman of the committee, Boston Elevated Railway, 31 St. James Avenue, Boston, Mass.

The Westinghouse Electric & Manufacturing Company has recently issued a 24-page, two-color, well illustrated booklet Circular 1664, entitled "Indicating Instruments for Direct and Alternating Currents." The introductory chapter includes a brief and interesting resume of the development of electricity with special reference to the development of alternating current and the earlier alternating-current instruments. One chapter is devoted to questions of standardization and sizes, insulation, compactness, readability, sturdiness, accessibility, simplicity, damping, accuracy and calibration. Another chapter offers a description in detail of the parts making the completed instrument. The last chapter is devoted to instrument applications.

A new concisely arranged service chart covering belt joining has recently been issued by the Crescent Belt Fastener Company. This chart is in card form, size 3½ by 9 inches and covers completely and specifically the means and methods to insure best results under all conditions of work. The indexing is by columns and covers all dimensions of belting from ¾ inch to 18 inches and larger in width. The specifications given cover leather belting in light, medium and regular; single, double and triple weights; and all kinds of fabric belting, rubber, canvas, balata, hair, etc., by plies. On the back of the card prices are given. This card is punched so it can be hung where convenient for reference, and in many of the larger companies these cards are placed at different points about the plants for ready reference by the men.

Copies can be had by requesting Form N. Y. 298 when writing to the Crescent Belt Fastener Company, 247 Park avenue, New York.

Railway Electrical Engineer

Volume 15 APRIL, 1924 No. 4

In another editorial in this issue entitled, "Welding Cast Iron," the importance of adequate supervision is pointed out. Of equally great importance is the training of operators. Unless a man is a skilled operator he can scarcely be expected to be an able welding supervisor. An extensive study of this subject has been made by the American Welding Society, and the results of the study were published in the Journal of that society for February. Qualifications of welders are defined and fundamentals in arc welding are explained. A course of training for welders is outlined and work is suggested for different grades or levels of welders. For each grade, types of welding work are suggested and means are shown whereby the instructor can check the skill and knowledge of the welder.

Training Arc Welders

The information included is not intended for use as a text-book for the student, since it does not undertake to furnish subject matter on electric arc welding, but it does point out the nature of the training required and the manner in which this training can be put into practice. There is a constant need for the training of operators in railroad shops, and for this reason the course outlined can probably be used to advantage by many of them.

The study of alternating current theory is generally considered difficult, and with good reason, for many of the electrical phenomena which occur in circuits carrying alternating current are far from easy to understand. Numerous attempts have been made in many different books and periodicals to explain the interesting conditions which arise in alternating current conductors and apparatus. Some of the methods used have been very ingenious and have helped materially in the understanding of this more or less complicated subject. It is believed that many of the readers of the *Railway Electrical Engineer* will be glad to learn that a series of articles dealing with the elementary theory of alternating current has been planned for their special benefit, the first article appearing in this issue. These articles have been prepared by K. C. Graham who, it will be recalled, was the author of a series of articles on direct current published some time ago in the *Railway Electrical Engineer* under the title of "Basic Principles for the Electrical Workman." It is Mr. Graham's aim to make the present series as simple as it is possible to make it and to carry the reader far enough into the subject that he can continue with the more complex phases if he so desires. Mr. Graham's style is clear and simple, as are his diagrams, and it is believed that this new series will prove beneficial to those of our readers who are interested in learning some of the whys and wherefores of alternating current theory.

"Alternating Current" Simplified

Electrical men will be interested in the news that the Baltimore & Ohio is going to begin work on the electrification of its lines on Staten Island, but somehow the project does not arouse the same enthusiasm that the Virginian electrification announcement did a year ago.

Baltimore & Ohio Electrifies on Staten Island

The plans of the Baltimore & Ohio are so obviously adapted to Staten Island and to no other portion of its lines that it seems almost as if it were an announcement of the continuation of the New York or Brooklyn subway system. The voltage plan for the new work is 600 volts d. c. and the cars are to be of a type that will be interchangeable with those of the Brooklyn-Manhattan Transit Lines. While there is no existing tunnel between Staten Island and New York or Brooklyn, it may be regarded as peculiarly significant that the type of cars chosen for this project should be suitable for operation on the lines of the Metropolitan subways. This applies only to the passenger service; no provision has been made so far for the freight yards which the company maintains in this territory.

Under the present day conditions of railroad operation, it is apparent that the big maintenance problem of train control is going to fall heaviest on the man who is responsible for the equipment located on the locomotive. Although most of the development of train control has taken place as an adjunct to the signal department, it is clearly obvious that the subsequent maintenance of that part of the apparatus which becomes so important a feature in connection with the air brake equipment will naturally be taken care of by the man who looks after the integrity of the other electrical equipment on the locomotive.

Train Control on the Locomotive

In investigating the matter of train control, the motive power representative must keep in mind a number of things. He must visualize the possibilities of serious delays in turning power both in connection with the original installation of the apparatus and of its maintenance. His study will probably show him that it will be desirable to install a system with the fewest parts

necessary to accomplish the purpose of train control and that these parts should be as rugged and simple in design as possible. He should see that the apparatus is designed to work properly in connection with any type of air brake equipment that may be used on his road, and that it does not deprive the engineman from assuming complete control of the air brake system in emergencies.

The maintenance of the apparatus will require suitable repair facilities located in appropriate quarters, and a force of skilled repairmen. If batteries are used, facilities must be provided for repairing them and charging them. The extent to which these facilities must be provided will depend largely upon the system of train control adopted, but with any system much of its success will depend upon thorough preparation for keeping the apparatus in good working condition.

There are other departments interested in train control problems besides the signal and mechanical, but it is doubtful if any will be called upon to shoulder greater responsibility for successful operation than will be the man whose duty it is to look after the proper functioning of the vital apparatus on the locomotive.

A. C.-D. C. Electric Locomotive

The Detroit, Toledo & Ironton now has electric locomotives under construction which will receive alternating current from the trolley and deliver tractive effort to the rail through direct current motors, according to the March 15 issue of the D. T. & I. Railroad News. The article in the News describes a test of the locomotive's electrical equipment which was conducted recently by the Westinghouse Electric & Manufacturing Company at East Pittsburgh, Pa.

The apparatus used for the test consisted of a New York, New Haven & Hartford locomotive designed to operate on 600-volt direct current power and a flat car coupled to the locomotive on which the apparatus for the D. T. & I. locomotive was mounted. The apparatus consists essentially of a 22,000/1200-volt transformer and a motor-generator set made up of a 1200-volt synchronous a. c. motor and a 600-volt d. c. generator. Power is thus taken from the trolley at 22,000 volts and 25-cycles and delivered to the motors as 600-volt d. c. power. This arrangement of course permits of field control, *i.e.*, supplying current at any voltage up to 600 to the motors by simply varying the field current of the generator. During the test the pantagraphs on the locomotive were used to collect the power from the trolley but were not connected directly to the apparatus in the locomotive. Instead the power was carried from the pantagraphs to the apparatus on the flat car and the power after being converted to 600 volts d. c. was passed back to the motors on the locomotive. The simple control apparatus necessary was mounted on the flat car.

Locomotives of this kind have been considered by engineers for a long time but until now no one has had the courage to build one for regular railroad service. There is no apparatus for the locomotive that has not been thoroughly tried out on other locomotives or as stationary equipment, but as yet no such large piece of rotating machinery as the motor-generator set has been placed on a locomotive. The set is about 15 ft. long by 6½ ft. in diameter and weighs nearly 32 tons. The rotor runs at 750 r. p. m. The effect of such a machine on a locomotive has not as yet been determined, but it is not so much larger than others that have been used previously as to make working out new difficulties appear impossible.

The advantages of such a locomotive are at once evident to the electrical engineer; a high voltage trolley is used which represents a saving in copper; direct current motors are used which have ideal characteristics for traction purpose with the added advantage in this case of field control which eliminates large complicated switches; and as the motor of the motor-generator set is a synchronous motor, the power factor of the locomotive can be kept up and line loss in the trolley reduced to minimum. These are marked advantages and if the locomotive proves successful, it will represent an important step forward in electric locomotive building.

Welding Cast Iron

Broken iron castings can be repaired with the gas torch using an iron or a Tobin bronze or some special alloy welding rod. They can also be repaired by means of the electric arc and an iron electrode. The best way to do the work is a mooted question, and the welder has to decide which one of the methods he is going to use.

Strictly speaking, the only way to weld cast iron is to preheat the casting to almost a red heat and weld with the gas torch and an iron welding rod. A good and dependable job can be done in this way without resorting to any of the tricks of the trade. Unfortunately, preheating usually necessitates removing the casting from the machine of which it forms a part, and preheating also usually causes a certain amount of warping of the casting so that machining is frequently necessary after the welding job is complete.

Repairing castings with the torch and a bronze or alloy rod is favored by many because the job can be done quickly, and the only preheating required is just enough to take the chill off the casting. When the work is done this way the casting is not warped and will not require machining afterward. Properly this should be considered brazing rather than welding, but as no flux is used many insist that it is a welding operation. The important thing is the result, and it may be said that the results are good. The repaired casting seems to be equally as strong as a new one and apparently will last indefinitely and not break down after being subjected to strain and vibration for long periods of time. The cost of doing the work in this fashion is probably the factor which limits its wider use. It was pointed out recently that although preheating was not necessary and less gas is used, the cost of doing the work with a bronze rod was greater than when the work was done with an iron rod because of the much greater cost of the bronze.

The advantage of doing the work with the electric arc is that the cost of power is less than the cost of gas, and the work can be done "in place," without removing the casting, and without any preheating. Using the arc, however, necessitates that the broken edges of the casting be drilled and tapped and lined with steel studs. Those who favor gas disparage this kind of work and call it "patch welding." It may be said, however, that if all such welds which have been made were suddenly to break down, the railroads in this country would be badly crippled for lack of motive power.

Reclaiming Damaged Locomotive Headlight Sets

Baltimore and Ohio Has Unusually Complete and Effective Facilities for Turbo-Generator Repair Work

Part II

THE methods used in the Cumberland shops of the Baltimore & Ohio for repairing governor valves are unique and the valves for all the sets on the railroad are repaired there.

A governor valve is usually repaired because the edges of the valve plunger and of the valve cage that throttle

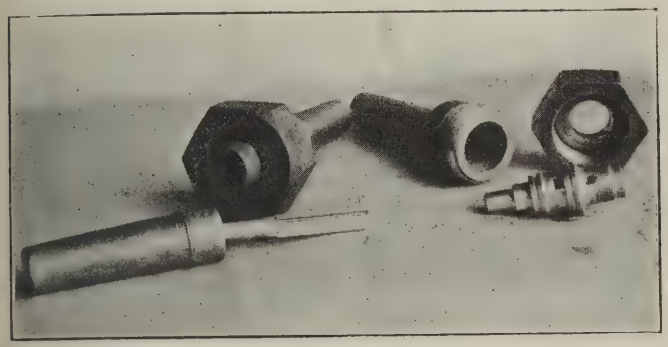


Fig. 1—At the Left Is a Floating Reamer and a Two-Part Chuck for Holding Valve Cages with a Cage in Place—At the Right Is a Valve Cage and the Two Parts of One of the Chucks

the steam are steam cut; worn away by the action of the steam.

A special two-part chuck shown in Fig. 1 is used to hold the valve cage while it is undergoing repair. The two parts of the chuck are shown at the right behind the valve cage. The inside of the longer part of the chuck is bored out to fit the valve cage and after the valve cage is placed

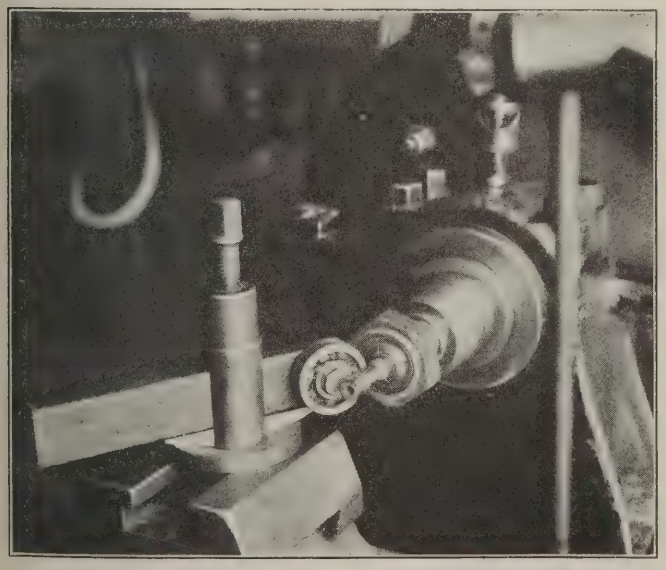


Fig. 2—Method of Upsetting Steam Cut Valves

in the chuck, the hexagonal cap is screwed down over the outside of the longer part of the chuck so that the valve cage is held firmly as shown at the left behind the reamer. The chuck is tapered to fit the live center of the lathe spindle.

After fitting the valve cage and chuck into the live center of the lathe, a 11/16 in. drill is put in place of the dead center of the tail stock of the lathe, and the valve cage is drilled out to a depth of 2 in. A cylindrical brass bushing is fitted into the hole made by the drill. The outside diameter of the bushing is such that it makes a driving fit in the valve cage.

To provide a proper fit for the valve in the bushing, the reamer shown at the left in Fig. 1 is used. The valve cage with the bushing in place is placed in the lathe chuck and the reamer fitted in place of the dead center of the lathe tail stock. It is important that the reamer be what is known as a floating reamer; that is that while the reamer will not turn in the tail stock it is free to swing laterally or vertically through a few degrees as if it were connected to the tail stock by a universal joint.

After the bushing is applied to the valve cage and

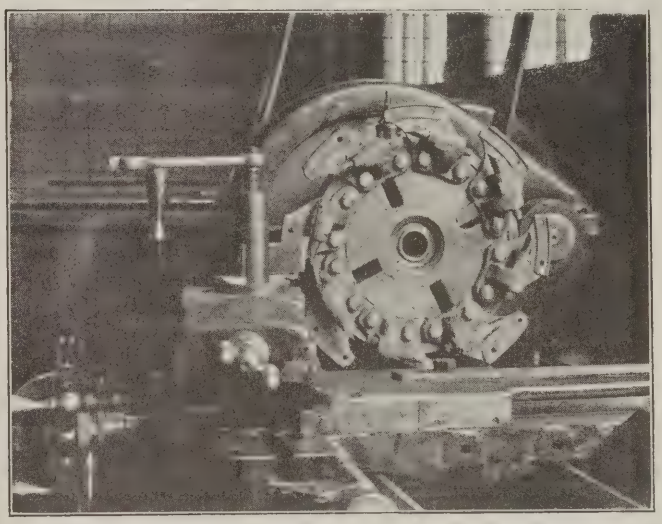


Fig. 3—A Special Lathe Face Plate Is Used for Machining Nozzles

reamed, ¼ in. holes are drilled into the side of the bushing through the ports in the valve cage. These round holes then become valve ports. As the valve is made by the manufacturers, the steam is shut off by pushing the valve into a hollow cylinder so that as the valve is closing, the steam is throttled in much the same way as it would be by a poppet valve. With the bushing applied, the action of the valve is that of an ordinary piston valve. After the ports are drilled, the bushing is again reamed by hand to remove the burrs caused by drilling.

There are two methods used for repairing steam cut valves. If the damage is slight, the steam cut edge is spun or upset to its original diameter by the process shown in Fig. 2. The valve is held in a special split chuck which in turn is held in the live center of the lathe spindle. The tool held in the tool post consists of a rectangular piece of steel with a ball bearing mounted at the end. As the valve is rotated, the ball bearing is pressed against the valve just under the edge which throttles the steam and the Monel metal of which the valve is made flowed or spun out so that the diameter of the valve at the edge is the same as it was originally. In case the diameter is in-

creased too much, the valve is turned down to the correct size in the lathe.

If the valve is too badly steam cut to be repaired by the above method, the throttling edge is turned down and is cut back to a point where the diameter of the valve has not been reduced by steam cutting. When the repair is accomplished by this means, the opposite end of the valve must be cut off just as much as the throttling edge is cut off so that the maintainers can set the valve by adjusting it to be flush with the top of the valve cage. Valves repaired in this fashion give highly satisfactory service and it is claimed by the repair men that they will provide closer regulation of speed and voltage than is possible with the

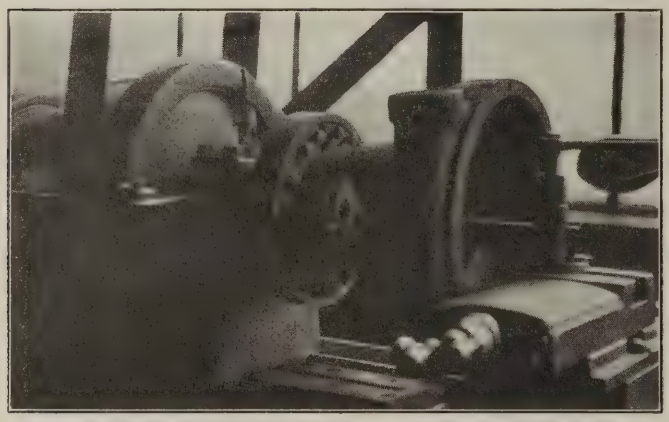


Fig. 4—The Face Plate Shown in Fig. 3 Is Also Used for Turning Nozzle Seats Which Have Been Worn and Built Up with Bronze

original valves. A turbine case without a cover, mounted on the assembly bench and connected to the air line is used for testing repair valves. This is shown at the left in Fig. 13. The purpose of this test is to determine whether or not the valve will close effectively.

Nozzles

If the guide passage plates and nozzles are steam cut or otherwise damaged, the pin which holds the nozzle is re-

Fig. 5—Jig Used to Hold Turbine Case for Boring Valve Chambers

moved. The plug back of the nozzle is then taken out, the nozzle driven forward the required amount and again drilled and pinned. The guide passage plate, if worn, is built up with bronze and the nozzles are then machined in wholesale quantities. Eight nozzles at a time are fastened to the edge of a special lathe face plate by means of a circle of cap screws near the outside of the plate and are turned down to the proper thickness and curvature. This operation is shown in Fig. 3.

Turbine Cases

Turbine cases are cleaned in the lye vat and are inspected for holes, broken feet, etc., and repaired with a

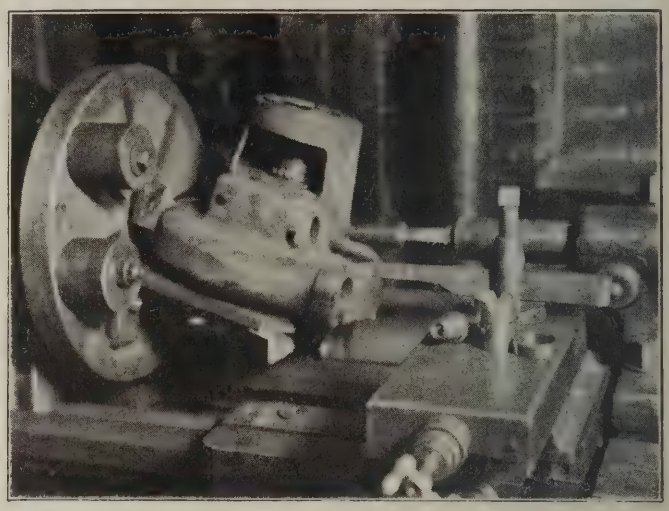


Fig. 6—Turbine Case in Place on Jig Shown in Fig. 5

gas welding torch. A Tobin bronze or an iron welding rod is used, depending upon whether the repaired part has to be machined or not. If necessary, the nozzle seats are built up with bronze after which the turbine casing is mounted on the same face plate that is used for shaping nozzles and turned down. This operation is shown in Fig. 4.

A method of repairing valve chambers which has not

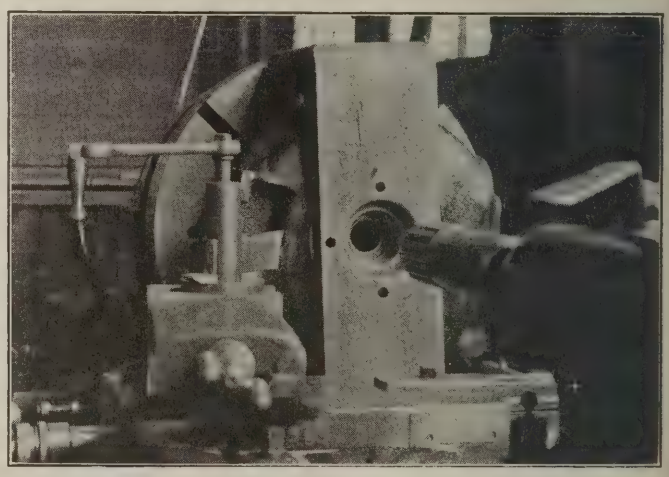


Fig. 7—Jig Used for Boring Generator Bearing Housing

been used extensively as yet has just been developed. The valve chamber is sometimes cut by steam getting out around the outside of the valve cage. A special jig, mounted on the lathe face plate is used for this job. The jig as mounted on the lathe is shown in Fig. 5 and the jig with a turbine casing in place is shown in Fig. 6. The tapered plug shown in place of the dead center is pushed into the valve chamber and it holds the turbine casing in alignment while it is being secured to the jig. Two weights, shown best in Fig. 6, are mounted on the lathe face plate to counter-balance the off-center weight of the turbine casing.

The first operation consists of boring out the valve

chamber and fitting it with a brass valve chamber bushing B, Fig. 5. This bushing fits snugly into the bored-out valve chamber and is held in place by the threaded bushing C, Fig. 5. The inside thread of this bushing fits the thread of the valve cap and the outside thread fits a corresponding thread cut in the enlarged valve chamber. The valve cap is used to screw the thread bushing into place and when it is down tight, a small drill is run down through the bushing and valve cage threads. A dowel pin is driven into this hole which secures the two bushings and allows the valve cap to be removed and reapplied when necessary. The valve cage A, Fig. 5, of course, fits the inside of the valve chamber bushing B.

When it is necessary, the bearing housing in the turbine case cover is bored out and fitted with a cylindrical steel bushing. The bushing is machined for a driving fit in the

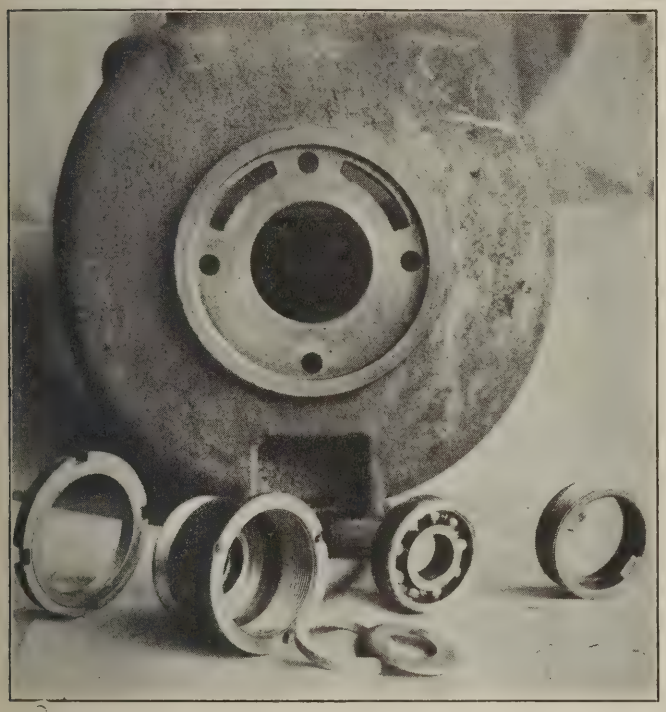


Fig. 8—Generator Frame With Bearing Housing Bored Out—Parts of Bronze Bearing Bushing and Bearing Shown in the Foreground

housing and after fitting in place is bored and reamed for the proper fit of the ball bearing.

Generator Frames

Broken generator frames are welded, hinge lugs and latch lugs, frequently broken, are welded on again and cracked castings are welded. If the condition of the generator bearing housing requires it, the housing is bored out to a diameter of 2-11/16 in. and fitted with a three part bronze bushing. The jig used for boring applied to a lathe with a generator frame in place is shown in Fig. 7. A generator frame, with the bearing housing bored out, is shown in Fig. 8. A bearing and a bushing are shown in the foreground. The bushing proper shown in the center fits snugly into the 2-11/16 in. hole in the generator frame and is secured by the lock ring shown at the left which screws over the outer diameter of the bushing inside the generator frame. The bearing is then slipped down into the bushing and held in place by the lock ring shown at the right which screws down inside of the bushing against the outer race of this bearing. The brass washer and felt washer shown in front are placed under the bearing in the bushing and prevent oil from the bearing working into the generator windings.

This method of securing the bearing precludes any possibility of creeping of the outer bearing race but the repair men claim, in this case at least, this does not have any detrimental effect upon the bearing.

Shafts

Shafts are most frequently damaged by being worn at the bearing fits or by being bent. When the part of the

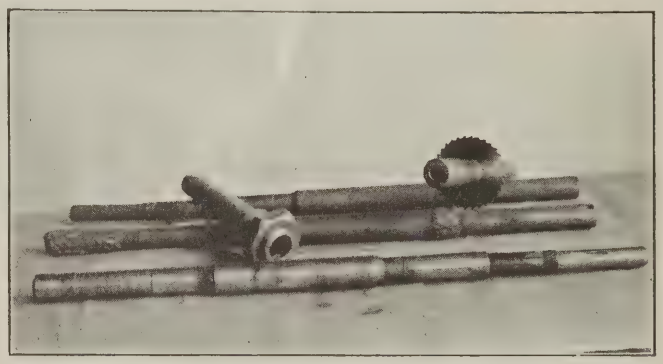


Fig. 9—A Damaged Shaft, a Welded Shaft, a Finished Shaft, a Chuck for Holding One End of a Shaft for Turning and a Miller for Cutting Key Seats

shaft inside the bearings is worn, the first repair operation consists of turning off the worn surface after which the turned down portion is built up with electric welding. The reason for turning the worn section first is that it is practically impossible to weld to the hard glazed surface of the worn shaft.

The building-up of the shaft by welding invariably warps the shaft to a certain extent and the shaft is straightened with a hammer and trued in a lathe. The next operation consists of turning the shaft down to size.

A damaged shaft, a welded shaft and a completely re-

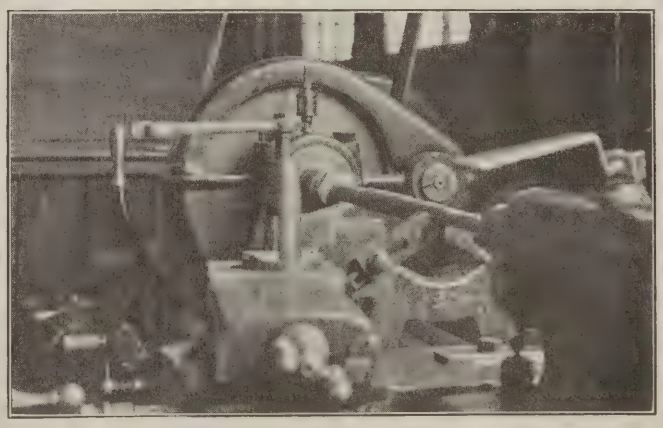


Fig. 10—A Shaft in the Lathe Ready for Turning; Note the Chuck and the Steady Rest

paired shaft are shown in Fig. 9. Lying on the shafts at the left is shown a chuck, or draw collar used to hold the shafts for turning. It is tapered to fit the live center of the lathe and the outer or tubular end is split by two saw cuts and has a taper thread on the outside. The larger end of the shaft is placed in the chuck and with a slight turn of the nut on the chuck tightens it on the shaft. The other end of the shaft is held by the lathe dead center. The operation of turning down a shaft is shown in Fig. 10. The steady rest prevents the tool from springing the shaft out of line while it is being turned.

A lathe is also used for cutting key seats in the shafts. The milling cutter shown at the right in Fig. 9 is chucked and centered in the lathe and a vise is attached to the tool post carriage. The end of the shaft is gripped in the vise and then the shaft is pressed against the milling cutter by raising the free end of the shaft. The operation is shown in Fig 11. The teeth of the cutter are of such a length that when the key seat is cut to the depth of the tooth it has the proper depth.

Governor Springs

Governor springs which have been distorted are repaired in the blacksmith shop. The springs are heated and

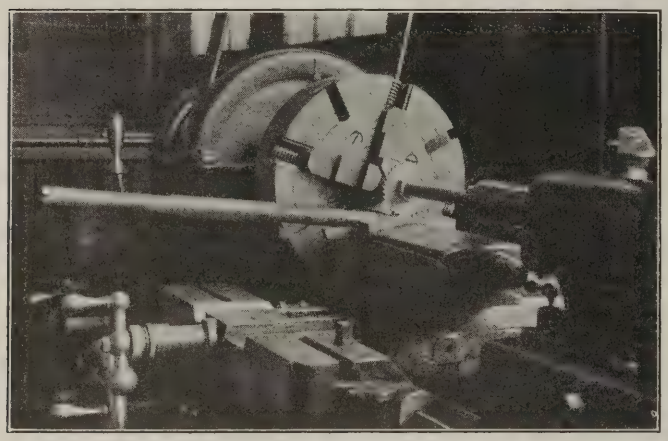


Fig. 11—Method Used for Cutting Key Seats

the coils closed after which the spring is retempered. The spring tempering job is one which requires considerable skill and knowledge of spring steel and is one which does not lend itself readily to description.

The spring is screwed into the governor sleeve and yoke and adjusted by means of the apparatus shown in Fig. 12. One of the springs is shown on a piece of steel shafting in the foreground. This piece of shafting has a ⅜-in.

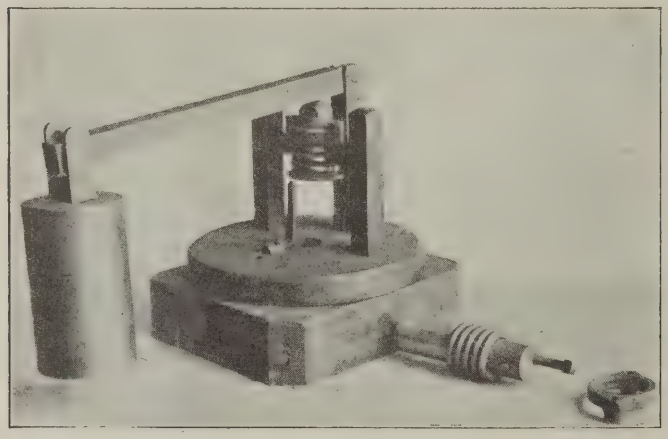


Fig. 12—Devices for Adjusting Governor Springs

hole drilled off center in one end and another ⅜-in. hole drilled in the side and connecting with the first hole. The hole in the end is threaded and fitted with a cap screw. The hole in the side is fitted with a piece of hardened steel with a chisel point. The inner end of the hardened steel piece is also beveled so that turning down the cap screw will cause the sharpened chisel point to protrude farther from the side of the shafting. The spring is slipped over the shaft, the point is made to grip the spring and the spring is held in this manner while it is screwed onto its seat.

After the spring is applied, it is placed in the testing device also shown in Fig. 12. The lever and weight cause a tension by gage to be applied to the spring which is just equal to the tension produced by the governor weights under normal governor action. It is necessary that the spring have a certain length under this condition and this length is measured by the gage attached to the base of the testing device. If the lower end of the governor sleeve is not depressed exactly to this gage, the spring is backed off or turned down the required amount.

When the turbine is assembled, the two adjusting screws which hold the tension on the governor spring is turned up until 7 threads protrude through the lugs on the governor yoke.

Assembling and Testing

The assembling and testing bench is shown in Fig. 13. It is a two-sided affair with a rack or row of bins for small parts down the center and a bench on either side, so that four men can work at it at once. Air and electrical connections are provided each workman for testing. Lamps in series with the electrical testing circuits prevent damage

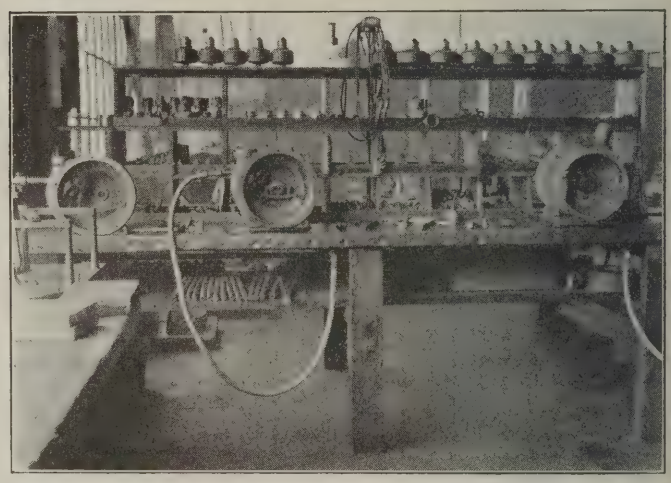


Fig. 13—The Assembling and Testing Bench

from accidental short circuits. To facilitate assembly, the sets are mounted on small turntables fixed to the bench so that the set can be rotated easily to any desired position. After the set is assembled, it is run with air and the governor is set to obtain proper voltage at the generator terminals. The machine is then given a coat of paint and sent out.

Complete repairs, except the rewinding of armatures are made at Cumberland. The armature winding is done at Bailey Station, Baltimore, Md., the general electrical repair shop for the eastern lines. The Cumberland repair shop is a room on one of the balconies of the back shop, 60 feet long and 28 feet wide. It is somewhat smaller than these dimensions would indicate as it is not rectangular. It is equipped with two lathes, one drill press, one small electric bench drill and a welding booth equipped for both gas and electric welding. Aside from the regular work on headlight sets, minor repairs to shop motors are also made in this shop, the work being done under the supervision of H. E. Childs, electrical foreman, with the aid of a suitable force of electricians and machinists.

Electric Operation of Paulista Railway in Brazil

Electrification Shows Large Savings on Road Which Must Use Wood or Imported Coal for Fuel

By Guy Bellows
Railway Engineering Department, General Electric Company

IN the early part of 1920 the Paulista Railway, Brazil, decided to electrify that section of its lines between Jundiahy and Campinas, a distance of about 28 miles. The section of the lines selected is double track and to a certain measure is the throat of the traffic from the interior of Brazil. While the Paulista Railway does not actually run into the city of Sao Paulo, the connecting link being the Sao Paulo Railway (double track), this section of Paulista Railway handles all the traffic from its feeders

A Train Load of Coffee and Cattle

and the Mogyana Railway from Campinas. The greatest point in favor of adopting electric traction was the high cost of fuel.

Both coal and wood are used. Coal is imported and wood is gradually growing more difficult to obtain with prices increasing in proportion. The economy therefore to be obtained from this source was well established.

Power for the electrification was contracted for with the Sao Paulo Light & Power Company. The material for the electrification was imported from the United States and consisted of 10 miles of 88,000-volt double transmission line, 4,500-kilowatt substation equipment, 27.3 route miles of double track 3,000-volt direct current trolley and distribution system and 16 locomotives. The total cost of the electrification, including all material, erection, construction, etc., was approximately $3,000,000.

The substation consisted of three units (motor generator sets) of 1,500 kw. each, making 4,500 kw. total continuous capacity, or 6,750 kw. for two hours. The locomotives consisted of 10 freight locomotives and six passenger type. Freight equipment was built for handling 772-ton (700 metric-ton) trains and passenger equipment for 441-ton trains.

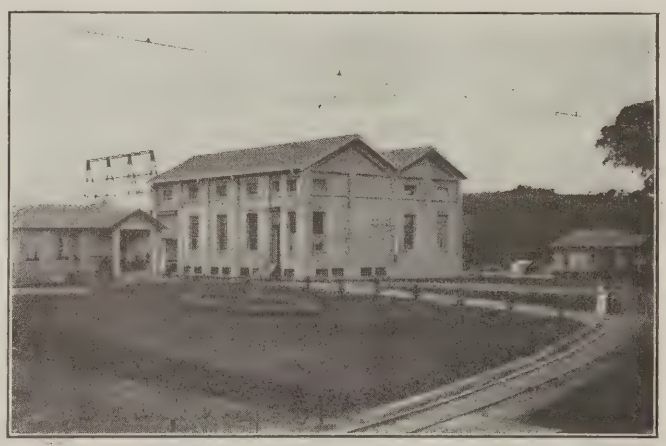
Service Requirements

Electric service on the line was started in November, 1921, on the part of the line then completed and continued in steps until the completed zone was inaugurated in June, 1922.

A comparison of the traffic at the beginning of the electric service with the final service after electric traction had been finally put in full swing is interesting. All freight trains are scheduled and run regularly and the schedule is maintained to a surprising degree of accuracy. When the electric service was started the schedule provided for 16 passenger trains and 50 freight, the latter including two of mixed service. After the electric operation was fully installed, the schedule was maintained for 20 passenger trains and 28 freight trains. The last schedule is taken as of July, 1923. During this period passenger traffic had increased materially and also there was a gradual increase in freight traffic. The reduction in number of freight trains was the result of increased tonnage per train and the more uniform and regular movements of traffic.

Locomotive Performance

The locomotives furnished for the service were equipped with regenerative control and while the grades are not



The Substation Located at Louviera

long, they reach maximums of 1.8 and 2 per cent and are of sufficient length to return power to the trolley in considerable quantity. Profile of the line is shown in the illustration. Train power consumption readings taken at the locomotives show that the average returned to the trolley in passenger and freight service amounts to 13.2 per cent. This includes the total for all switching and handling of locomotives at terminals and engine houses. While these averages show the return at the locomotive, it is interesting to note that less than 5 per cent of this energy is returned to the power company's lines, showing that the railway company is obtaining almost full benefit from the regeneration since the greater per cent is used direct from the trolley. In addition to this economy there is also the saving on brake shoes and maintenance of braking appa-

ratus which is perhaps the more important of the two. Table I shows the averages of a typical month's service and includes the power consumed at the locomotive in all switching and stand-by losses of the locomotives handling through services. Actual yard switching in Campinas and Jundiahy is still handled by steam locomotives, but equipment for this service has been ordered. The power actually consumed as measured on the power company's incoming lines covering the same month as the locomotive values given in Table 1 was 796,600 kilowatt-hours.

Table 1 shows the power consumption and power regenerated at the locomotives for one month's service measured on passenger and freight equipment. All of the locomotives were equipped with standard railway type kilowatt-hour meters excepting two passenger and two freight and corrections have been made to include their consumption on the basis of their services averaged in proportion to the total averages of the other locomotive equipped with meters.

TABLE 1

Class of Service	KWH. Motoring	KWH. Regenerating	Per Cent Regenerating
Passenger	303,510	30,505	10.05
Freight	363,595	57,530	15.82
Total	667,105	88,035	....
Average per cent regeneration	.....	.....	13.20

It is worth while to call attention to the power rates as affecting the railway company. For the period from 6 a. m. to 9 p. m., power is paid for at a maximum rate. From 9 p. m. to 6 a. m. the rate is reduced approximately 14 per cent. On Sundays and holidays the maximum rate given above (6 a. m. to 9 p. m.) applies for the full day. Maximum and minimum power demands are specified as well as a load factor between 6 a. m. and 9 p. m.

The above restrictions are in keeping with the customs

An Electrically Operated Passenger Train

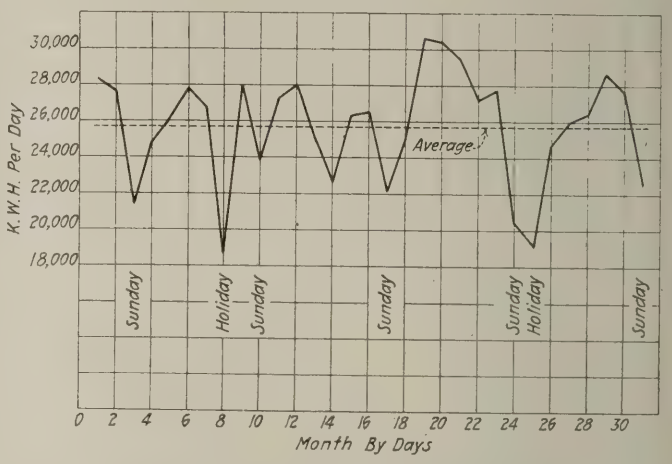
and manner of handling traffic. On Sundays and holidays traffic is cut down so as to include only passenger trains, essential perishable goods trains and stock trains. On national holidays, special effort is made to keep freight trains to the absolute minimum.

A comparison of power measured at the locomotives to that actually measured on the power company's lines is of special interest, since it shows a ratio of 0.837. This ratio brings out the high economy possible with regeneration and also shows that the regenerated power is taken almost entirely from the trolley giving the railway company the greatest benefit and highest economy.

Costs

A typical monthly power consumption is shown on the accompanying curve. This curve shows the low power consumption on holidays and Sundays in keeping with the manner of handling traffic as mentioned above.

Special tests in freight and passenger service made by the engineers of the railway company, in conjunction with the manufacturer's representatives show remarkably efficient operation. Results of these tests in both passenger and freight service are given in Table 2. The figures given in each case are averages of a sufficient number of



Typical Power Consumption Curve for One Month. Points on Curve Represent Total Daily Consumption

trains to eliminate errors and establish accurate data on the performance of their equipment.

The railway company made a careful study of the service on the electrified zone as compared with steam operation, on the basis of one year's operation, equivalent to 465,750 miles. Table 3 shows the cost of operation for steam operation and Table 4 shows cost of electric.

From a comparison of Tables 3 and 4 it will be seen that the cost of the electric operation is approximately one-third that of steam and that the cost of power for the electric is approximately one-fourth that of the cost of coal.

Table 5 shows the comparison of heavy maintenance of steam and electric based on a year's service of train miles.

The cost of operating and maintaining the 10 miles of high voltage (88,000) transmission line and the 71.4 miles of secondary distribution system for one year of 465,750 train-miles is shown in Table 6.

TABLE 2—AVERAGES OF SPECIAL TESTS—FREIGHT AND PASSENGER SERVICE CIA PAULISTA DE ESTRADAS DE FERRO

	Freight service	Passenger service
Distance of run, miles	27.4	27.4
Weight of locomotive, tons	99	120
Tonnage of trailing train	712	455
Tonnage of total train	812	575
Ton-miles trailing	19,500	12,470
Ton-miles total	22,250	15,750
Kwh. input at locomotives	571.8	509.0
Kwh. regenerated at locomotive	156.8	73.0
Kwh. net at locomotive	415.0	436.0
Per cent regeneration	27.38	14.3
Net watthours per trailing ton-mile	21.3	35.0
Net watthours per total ton-mile	18.65	27.7
Number of runs	5	12
Number of cars in train	22	12
Number of delays or stops per run	0.6	1.0
Total time of run in minutes	73.4	44.75
Time delayed on stopped—minutes	4.2	2.0
Running time, minutes	69.2	42.8
Maximum speed, m.p.h.	31.1	49.7
Average speed, m.p.h.	23.7	38.4

TABLE 3—COST OF STEAM OPERATION

	Total cost 465,750 train miles	Per train mile
Coal 22,040 tons (20,000 metric tons)	$238,095	51.14c
Engine drivers and firemen	29,762	6.38
Mechanics and helpers (running maintenance)	13,227	2.84
Locomotive wipers	2,679	0.57
Lubricants and miscellaneous material	10,089	2.16
Total	$293,852	63.09c

TABLE 4—COST OF ELECTRIC OPERATION

	Total cost 465,750 train miles	Per train mile
Power—paid for at power company lines	$47,381	10.18c
Transformation of power from 88,000 V.A.C. to 3,000 volts D.C.	8,343	1.79
Engine drivers and assistants	19,024	4.08
Electricians and mechanics (running maintenance)	2,931	0.63
Locomotive wipers	1,640	0.34
Lubricants and miscellaneous material	10,607	2.28
Total	$89,926	19.30c

TABLE 5—REPAIRS AND HEAVY MAINTENANCE

	Steam		Electric	
	Total cost 465,750 train miles	Per train mile	Total cost 465,750 train miles	Per train mile
Labor	$13,512	2.90c	$6,250	1.34c
Material	18,303	3.93	3,928	0.84
Total	$31,815	6.83c	$10,178	2.18c

TABLE 6

	6.2 miles of 88,000 v. Transmission Line		71.4 miles Secondary Dist. System	
	Total cost 465,750 train miles	Per train mile	Total cost 465,750 train miles	Per train mile
Labor	$1,865.00	0.40c	$4,271.00	0.91c
Material	272.50	0.06	559.50	0.12
Total	$2,137.50	0.46c	$4,830.50	1.03c

TABLE 7

	Cost per train mile	
	Steam	Electric
Operating trains	63.09c	19.30c
Locomotive repairs	6.83	2.18
Transmission line operation and maintenance	....	0.46
Trolley line operation and maintenance	....	1.03
Total	69.92c	22.97c

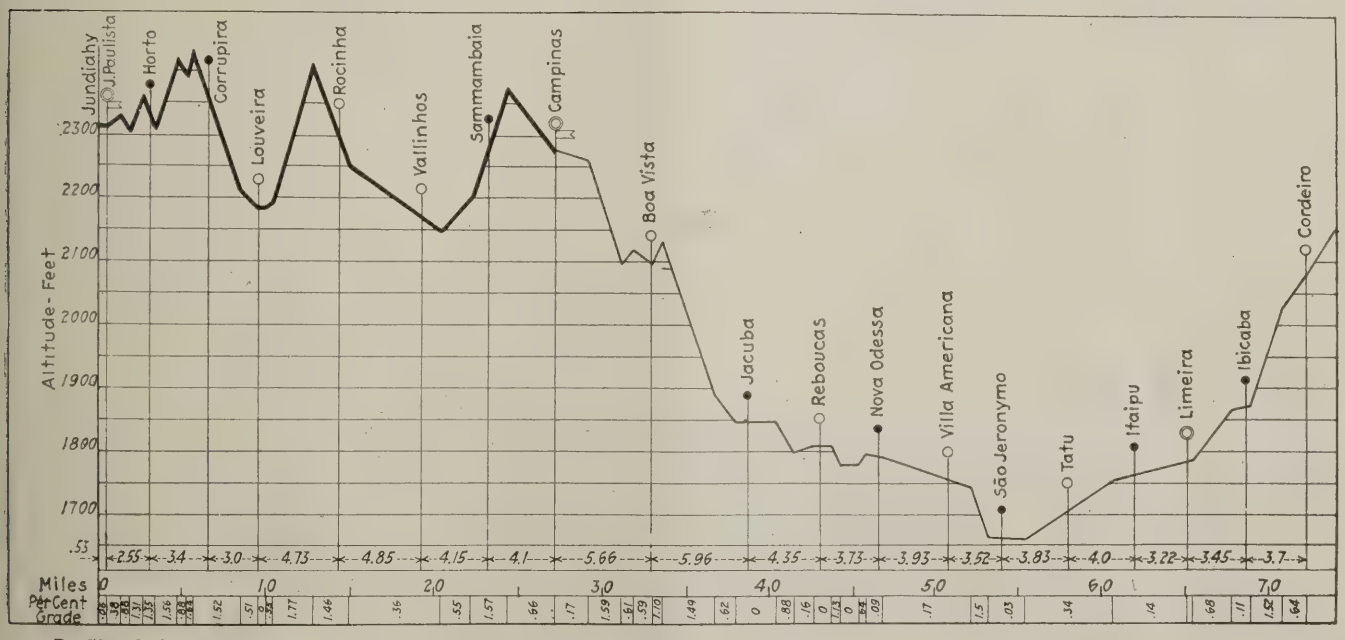
For the final total economy of electric service over steam, Table 7 shows the costs on the basis of a year's service or 465,750 train-miles.

As a result of the saving shown by the initial installation, the Paulista Company decided to extend its electrification and in the early part of 1923 orders were placed for the material for electrifying 50 additional route-kilometers of single track. This included 88,000-volt high tension line, secondary distribution and 3,000 kw. substation materials, also five 3,000-volt d.c. switching locomotives.

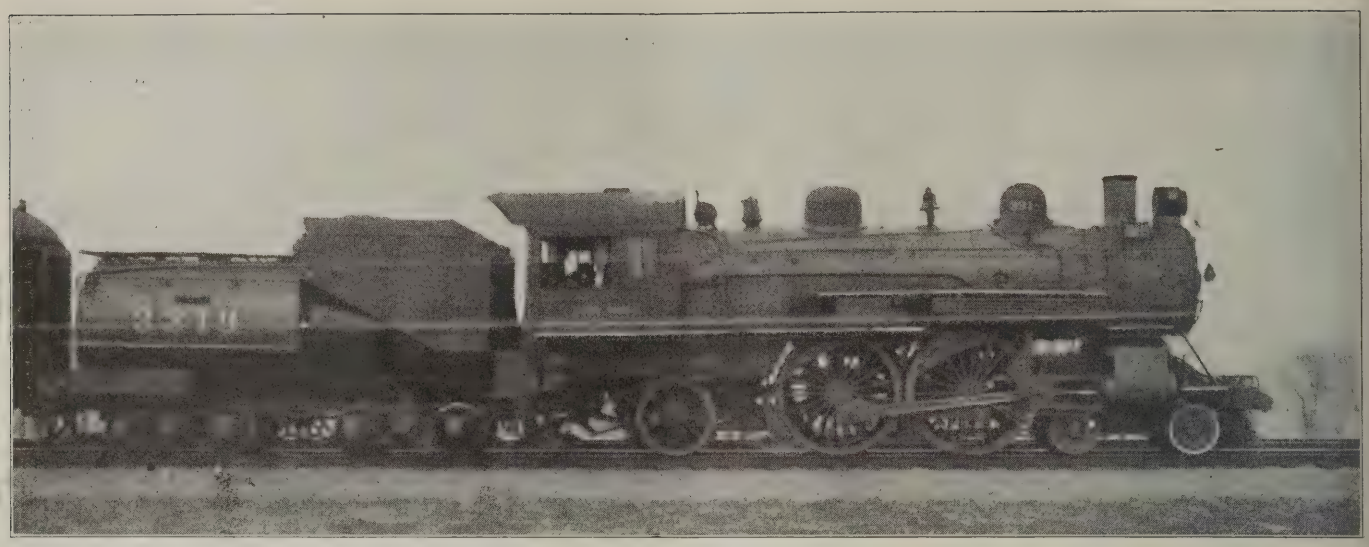
Costs and performance data in this article have largely been taken from the report of Eng. F. de Monlevade, Inspector Geral da Companhia Paulista de Estradas de Ferro published in the Revista Brasileira de Engenharia.

The costs given on maintenance and operation are based on an exchange of 8 milreis equal to $1.00, which is the average exchange over the period for which the costs are given. While the comparison of steam and electric service are exact, the costs in American money are not strictly comparable with services in this country, due to the varying exchange.

Fuel Pile and Wood Burning Locomotive on the Paulista Railway



Profile of the Section of the Paulista Railway Between Jundiahy and Cordeiro. Electric Section Is Shown by the Heavy Line



Right-Hand Side of Locomotive Showing National Inductor Plane, The Miller Shoe and the U. S. & S. Co. Apparatus in Case

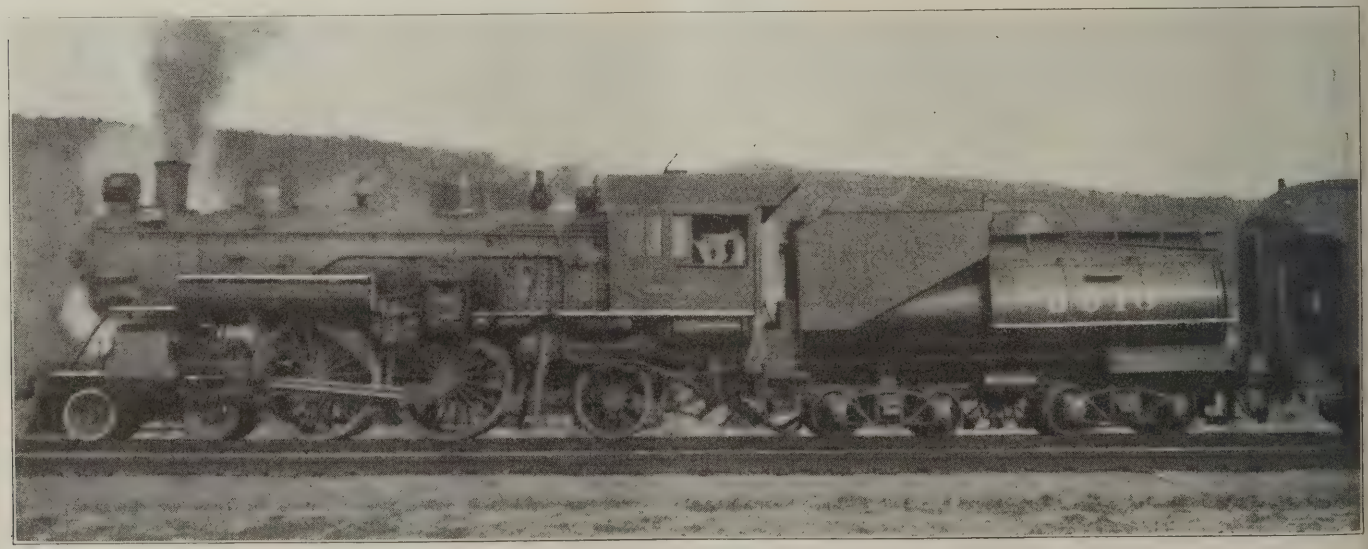
Train Control Test Engine on the U. P.

Locomotive Fitted With Three Types of Devices for Making Comparative Tests Between Systems Installed Adjacently

IN order to determine the device suited to its conditions, the Union Pacific is conducting tests with three kinds of train control equipment. Apparatus of the continuous induction type, the intermittent electrical contact type and the intermittent induction type was installed along the roadway and on an engine. The devices selected by the Union Pacific for these tests were manufactured by the Union Switch & Signal Company, the Miller Train Control Corporation and the National Safety Appliance Company. The installation was made so that the engine could be operated over adjacent territory on which the roadside apparatus of the three companies was installed. The test engine was used in double-heading trains, both freight and passenger, east and westbound over this district. In addition, many test runs were made with the engine and one or two coaches. Observations of all tests were made and recorded.

Where the Installation Was Made

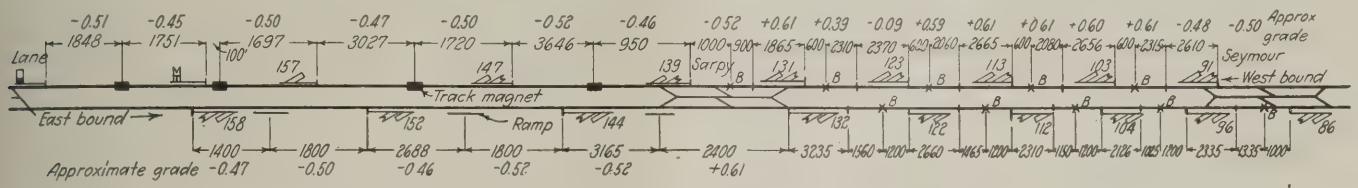
The territory selected for the installation was between Seymour, Neb., and Lane, a distance of approximately eight miles. Seymour is about seven miles west of Omaha. The line is a double track line equipped with two position signals with the home and distant signals on one mast. These signals are spaced approximately one mile apart. Between Seymour and Sarpy, both the eastbound and westbound mains are equipped with the continuous induction control. Five signal locations in each direction are involved in this installation. Lower quadrant two-arm signals are in service over this territory.



Left-Hand Side of Locomotive Showing U. S. & S. Co. Pneumatic Valve Ahead of the Pumps and National Inductor Plane Under Tender

Proceeding west, the westbound main track between Sarpy and Lane has been equipped with the intermittent induction control. Four signal locations are included in this installation. The last two track elements govern the approach to the westbound home signal for Lane interlocking plant.

The intermittent electrical contact type is in service on the eastbound main track between Lane and Sarpy. For this installation, three ramps have been installed so that they are located at braking distance from the signals.



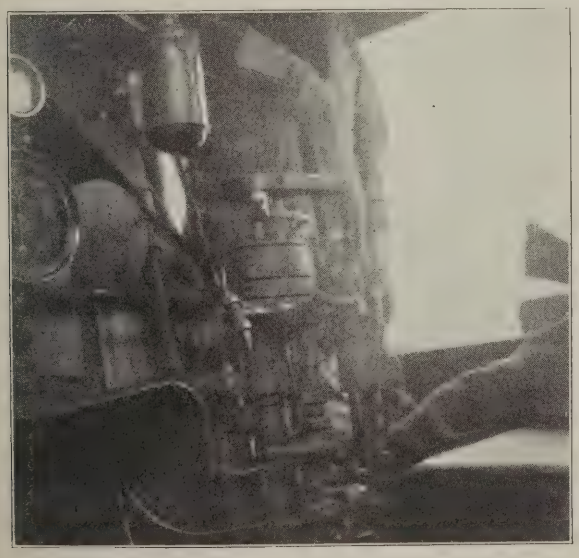
Track Plan Showing Location of Ramps, Track Elements and Superimposed Track Circuit Territory

The track diagram shows the signal layout, the grades and the territory over which each of the installations are installed.

How the Engine Is Equipped

In equipping the locomotive with the engine apparatus of the three companies, provision was made so that the different parts would not interfere. It is unnecessary to cut out or cut in the different devices on the engine in passing from one section of track to another section which is controlled by a different kind of roadside equipment. In this way, continuous tests can be made with each device functioning, independently of the other two, over its respective territory. Atlantic type engine No. 3318 was used for test purposes.

The inductor planes of the National Safety Appliance Company are located under the tender between the front and rear trucks. The pneumatic valve is located under

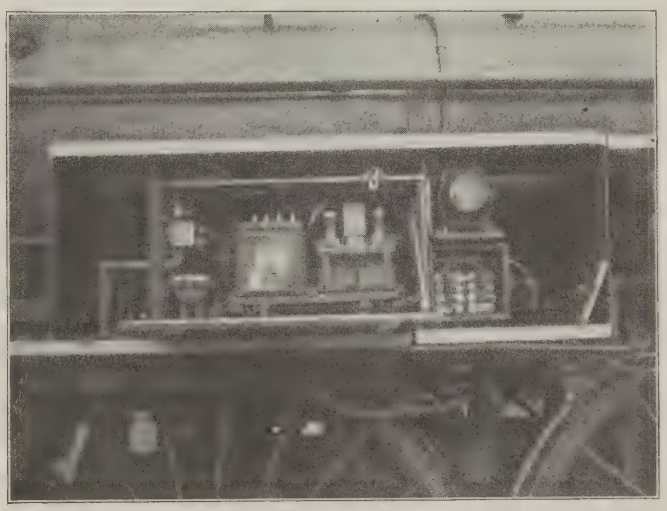


The Engineman's Brake Valve Equipment

the engineman's brake valve and the release valve is placed under and outside of the cab; this makes it necessary for the engineman to get down to the ground to effect a release.

The contact shoe of the Miller Train Control Corporation device is placed on the right hand front truck frame of the tender, with the air and wire lead going up to mechanism for the operation of the engineman's brake valve handle. This mechanism is located alongside of the brake valve with connections made on top to the brake valve handle. The positive stop valve is located outside and underneath the cab, making it necessary for the engineman to get on the ground to release himself after a stop.

In the installation of the Union Switch & Signal Company apparatus, the track coils are placed ahead of the pony trucks on the locomotive. The local coils are placed between the trailer wheels on the engine, and the tender, while the back-up track coils are placed back of the last truck on the tender. The speed control apparatus consists of two governors, the protection governor and the speed control governor. The speed control governor is



U. S. & S. Co. Equipment Case on Running Board

attached to the engine frame by two large brackets and is located ahead of the first pair of drivers and underneath the boiler. This governor is driven from the rear pony wheel axle of the engine through the medium of a transmission drive and universal joints. The protection governor is mounted on the rear pony wheel axle of the engine and is driven by it. The equipment case is placed on the running board on the engineman's side with a section of the running board built over the top of the case. This horizontal case contains the motor-generator, amplifying tubes, the relay, the condenser and the wire terminals.

The pneumatic valve is placed on the left side of the engine and hung from a large bracket which is attached to the bottom of the running board. The engineman's acknowledging valve is in the cab near the brake valve and of easy access to the engineman. The cab signal lights are mounted in the front end of the cab in a position to be easily seen by the engineman.

Electric Arc Process for Scrapping Steel Cars

Method Is Less Expensive Than Others Where a Large Number of Cars Is to Be Handled

By A. M. Candy
General Engineering Dept., Westinghouse Elec. & Mfg. Co.

IN the past it has been the practice to turn steel cars ready to be scrapped over to wrecking companies or car builders. As a result many thousands of dollars profits have been made by such companies which could be made just as well by the railroads if they would make the necessary capital investment to do the work. A few of the roads have already investigated this question and have put in efficient equipment.

The problem of handling cars to be cut up is divided into two quite distinct fields, namely, reclaiming and scrapping. When a car is in such condition that the side stakes and

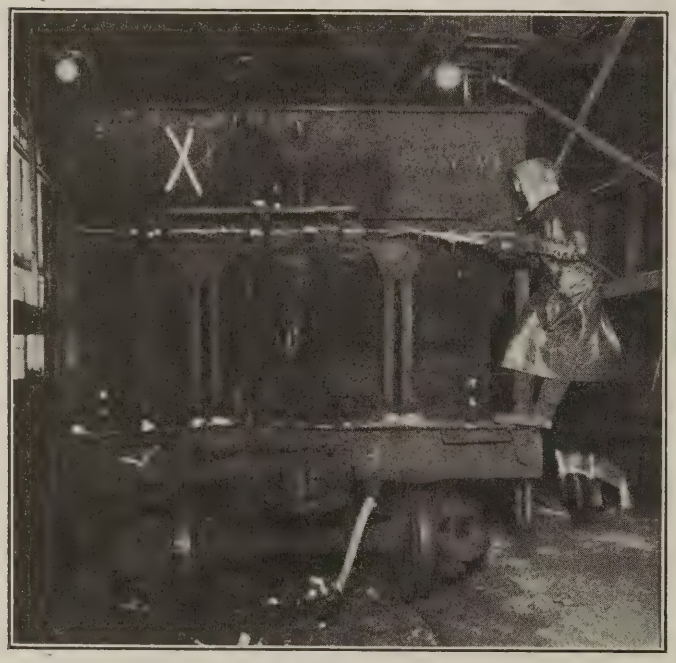


Fig. 1—Interior of a Building Equipped with Traveling Resistors for Use in Cutting Up Steel Cars by the Arc Process

underframe are in a satisfactory state of preservation, the car is a subject for reclamation, the work required being that of cutting rivets and bolts so that the defective plates and fittings can be removed readily and new material re-riveted in position. In many instances, however, the cars are in such poor condition that the only salvage will be trucks, air brake equipment and possibly center sills. Such a car, therefore, is a straight scrap problem and can be disposed of much less expensively by straightaway cutting of plates, stakes, angles, sills and other parts in the shortest time.

There are three general methods employed for cutting up steel cars, namely, air guns or "rivet busters," oxy-acetylene cutting torches and the electric arc. It is not sufficient to say that any one of these processes is the best or the cheapest, because it will be found that there is a field for each. Insofar as the actual operating cost is concerned, the arc process, however, is actually cheaper. On one road the cost of cutting 200 rivets ¾ in. in diameter was found to be as follows:

Labor, 1 hr., 3 min. at 90 cents an hour	$0.945
Electric power	0.800
Backing off rivets	0.660
Total	$2.405

A typical installation for reclaiming cars using the arc process for rivet cutting is shown by Fig. 1. Platforms at a convenient height are provided along both sides of the cars so that the operators can readily reach all the rivets. The resistor through which each operator obtains his cutting current is mounted overhead on wheels on a monorail so that it can readily be moved along the length of the car by the operator. The cutting cable is supported by the

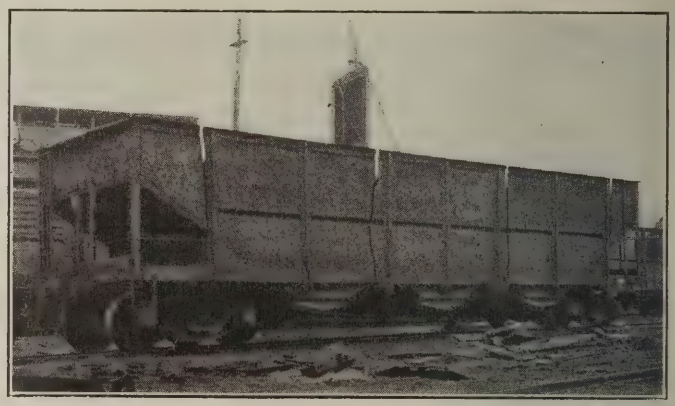


Fig. 2—Car with Rivets and Plates Cut Ready to Be Broken Down

resistor carriage which relieves the operator from dragging long cable leads over the floor. Four motor-generators operated in parallel to deliver 1,000 amperes each, provide capacity for a total of eight cutters at one time, using from 400 to 600 amperes each.

The building illustrated is used exclusively for the work of cutting off the rivet heads. The cars are then removed to another building where the rivets are backed out by means of air guns, the old plates are removed and new plates riveted in position.

At another installation where cars are scrapped, some rivet heads are cut off, but in addition sufficient cutting through the plates and angles is done, as shown in Fig. 2, in a building similar to that illustrated above, so that the cars can be switched under a crane way as shown in Fig. 3. The car sides are then knocked out by the crane operator, swinging a large skull cracker ball through the sides of the car. In a few minutes' time the car is reduced to the condition shown by Fig. 4 where a gang using a rivet gun is shown cutting the few remaining rivets necessary for the complete destruction of the car. Actual records at this plant show that ten men can cut up 36 cars per 22-hr. day. Individual records show that the various operators

will cut from 1,800 to as high as 3,100 rivets ⅝ in. in diameter per 10-hr. day.

The time required to cut up the car depends entirely on the number of pieces into which the car is cut, or, in other words, the number of feet of cutting. In some instances as high as 240 ft. to 250 ft. of cutting is being done on 40-ft. coke cars, whereas by careful analysis this same car

Fig. 3—Breaking Down the Car Body with a Skull Cracker

can be cut into 14 pieces, involving 177 ft. of cutting, the pieces being sufficiently small to load in a car. This cutting can be executed by one operator in 3½ to 4 hours' time, the cost of labor and power not exceeding $6.75 to $7.00, based on labor at 60 cents an hour and power for the motor generator equipment at 2 cents a kilowatt-hour.

The size of the pieces into which a car must be cut is

Fig. 4—Cutting the Few Remaining Rivets in the Hoppers with Pneumatic Hammers

entirely dependent upon the material handling facilities of the company receiving the scrap. In some extreme cases, it will be found permissible to cut a car straight through from side to side, cutting it into three or four sections, the sides of which can be mashed over against the bottom where a crane is available to swing a skull cracker ball or an old truck.

One railroad has found that it is only necessary to cut hopper bottom cars at the corners and around the sides just above the bottom, leaving the sides, ends and bottoms full size, approximately as follows: Sides, 30 ft. 5 in. long by 9 ft. wide; bottom, 30 ft. 5 in. long by 9 ft. 6 in. wide; ends 9 ft. 6 in. long by 4 ft. wide. Gondola cars are cut at the corners and the sides and the bottom is cut across the center, making the sizes of the parts approximately as follows: Sides, 20 ft. long by 4 ft. wide; ends, 9 ft. 6 in. long by 4 ft. wide; bottoms, 20 ft. long by 9 ft. 6 in. wide.

When planning an electrical installation for rivet cutting or car scrapping work especial consideration must be given to the distribution system on account of the relatively high current values used and the relatively low generator voltage. Each cutting arc will be operated at 400 to as high as 800 amperes and the generator voltage will be approximately 60 volts. Where a number of cutters are employed the current to be handled will, therefore, run into several thousand amperes which will require the use of ample copper cable to keep the voltage drop within permissible limits —not to exceed 5 per cent of the generator voltage at the point where each arc is to be used. When the track is to

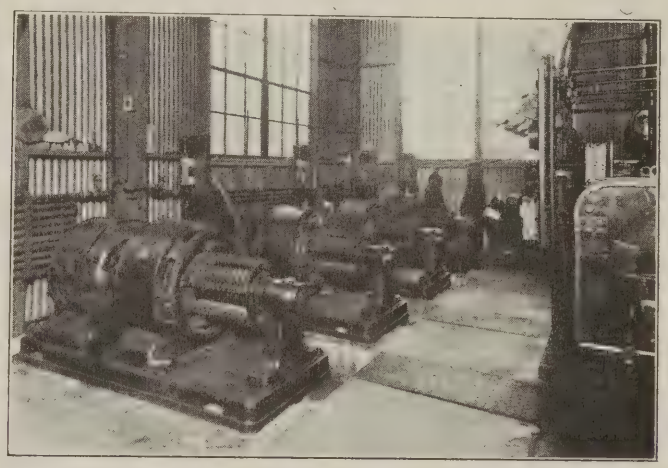


Fig. 5—A Group of Four Motor-Generators for Welding Service with Control Switchboard on the Right

be used as a part of the transmission system all joints must be heavily bonded. In some installations no special provisions are made for conducting the current from the car body to the rails, but it is allowed to flow through the truck center bearings, journals and wheels to the track. This, however, in some cases at least, is not entirely satisfactory and results in unnecessary loss as the voltage drop through the truck center bearings is considerably higher than at any other part of the car body.

To assist the operators in the cutting work it is advisable to have suitable scaffolding or platforms provided along the sides of the cars at a height of about 6½ ft. Each operator will require a cutting resistor which will have considerable weight. Therefore, it is advisable to locate a number of these resistors on about 40 ft. centers under the platform so that they will be protected from the weather. A suitable terminal should be provided at the resistor so that each operator can readily connect his cutting holder cable to the resistor.

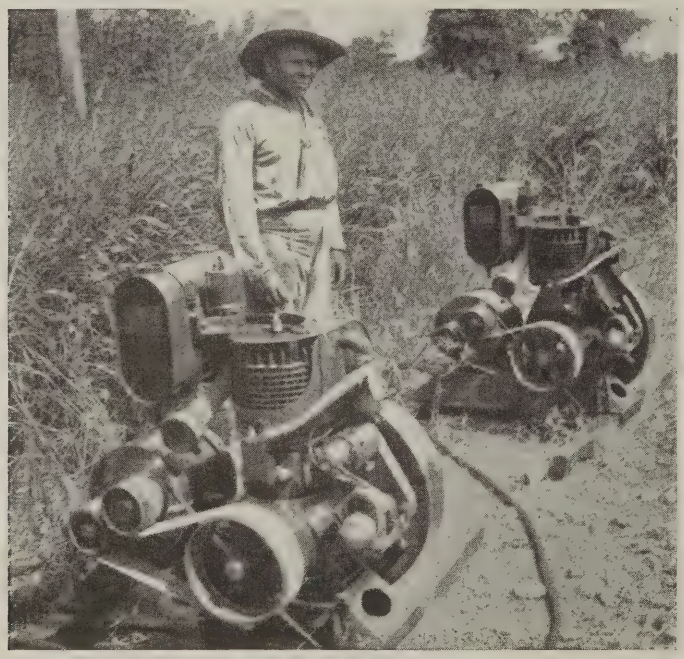
The motor-generator and switchboard equipment should be located in a building which will give the apparatus complete protection from the weather, as shown in Fig. 5. This also centralizes the equipment so that it can be given

the proper attention by a competent electrical attendant. It is usually advisable to install two or more motor-generators of say 1,000 amperes capacity each, to be operated in parallel when the current required is in excess of 1,000 amperes rather than one large machine for several reasons. First, if one machine should fail, the plant can still be operated at a reduced capacity. Second, such a plant can be operated more efficiently because if the work for a given day demands only a portion of the available capacity, only a portion of the sets need be operated.

Electric Tie Tampers Show Economies

An average cost of $180 per mile for general surfacing operations on 14 miles of rock ballasted track is a record obtained on a southwestern road last season with electric tie tampers. It serves not only as an illustration of the economies to be obtained through the application of mechanical equipment to track work but, also, marks the tendency toward the use of the equipment on a more intensive basis by providing enough power tools for an entire extra gang so that all of the tie tamping may be done mechanically.

The standard outfit furnished by the Electric Tie Tamper and Equipment Company, Chicago, embraces a gas-engine generator set capable of supplying current to four electric tampers and in a number of cases, a sufficient number of four-tool outfits were furnished to the extra gangs to do all the tamping required.



Two Generators Driven by New-Way Engines

In place of operating four tampers, as is customary in ordinary section work, the most satisfactory results were obtained by working the tampers in batteries of eight, four machines operating on each tie outside the rail and four other machines working on the same tie inside the rail, as illustrated in one of the photographs. Another of the illustrations shows how the two power units are placed on the shoulder of the roadbed in a convenient location with respect to the position of the gang.

It is said that the day's output which may be expected from one eight-tamper crew varies from 1,000 to 2,500 ft., depending on the lift and the kind of ballast. If experience indicates that each eight-tamper gang will complete 1,000 lin. ft. per day, the gangs are spaced 1,000 ft. apart when the work is started in the morning. Therefore at the end of the day, five eight-tamper gangs will complete work on almost a mile of track.

One advantage in the handling of mechanical tamping by extra gangs with the use of the four-tamper power unit lies in the fact that these four-tool outfits can be assigned to section gangs whenever it is found advisable to discontinue the extra gang operations. No difficulty is experienced in transferring the power units over the line since they are of such size and weight that they are easily handled by two or three men and can be readily transported over the line in a one-man, side drive inspection car.

How Eight of the Tampers Are Used on One Tie

Where the tamping outfits are to remain with a large gang permanently, it has been found of advantage to provide a power plant consisting of a 20-hp., four-cylinder, automobile type engine arranged to drive on a 8-kw. generator, mounted on a special car as illustrated in one of the photographs. A power plant of this kind was fitted up on the Santa Fe to provide current for 16 tampers and was used for this purpose during the past season, and, also, to provide current for driving screw spikes. General experience with the tie tamper during the past season has shown that the cost of surfacing done in connection with ballasting ranges from $180 to $300 per mile and has effected a material saving over the cost of performing the same work by hand.

Czechoslovakia, in her efforts to conserve coal and to reduce cost of manufacturing, is turning to her water power resources and is endeavoring in every possible way to increase the use of such power throughout the Republic, says Consul C. S. Winons in a report from Prague. In furtherance of this purpose a dam is being built across the Valley of Cerna Desna, in Northern Moravia. The building of this dam will cost approximately 7,500,000 crowns, of which 40 per cent will be supplied by the government. Other water power developments are being planned by the government to be carried out during 1924.

Elementary Theory of Alternating Currents

A Series of Practical Articles Explaining a Difficult Subject in a Simple Manner

By K. C. Graham

Part I

THE study of alternating current theory is usually looked upon as a very difficult undertaking, but if it is approached in the same manner that we took up the study of direct currents we shall not have any particular difficulty in understanding this branch of electricity.

It will be recalled that a direct current is one whose

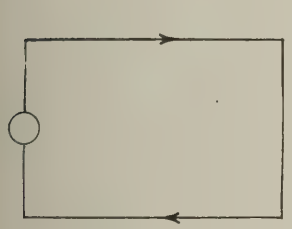


Fig. 1 (a)

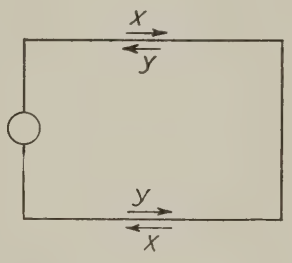


Fig. 1 (b)

direction of flow is always the same or constant, as it is expressed, while an alternating current is one that is continually changing from one direction to the other.

This may be readily seen upon referring to Fig. 1 (a) which shows a current flowing through the circuit in the direction indicated by the arrow. In Fig 1 (b) the *x*

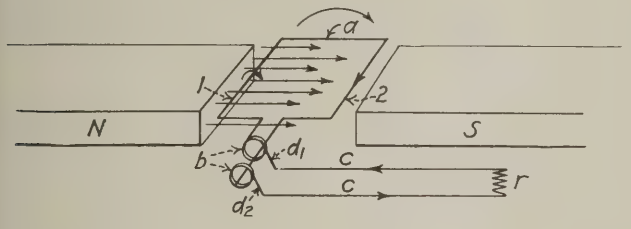


Fig. 2

arrows show the direction of flow at one instant while the *y* arrows show it at the next instant so that it is continually changing or alternating from one direction to the other—hence its name *alternating current.*

Before proceeding further with our study it might be well to discover how such a current exists, or in other

Fig. 3

words, how it is generated, and for this purpose it will be necessary to refer to Fig. 2.

N and *S* are the north and south poles respectively, of a generator, *a* is the revolving loop which terminates in two rings *b b* from which the current is collected by means of brushes d_1 and d_2 whence it is passed to resistor *r* by conductors *c c*.

The lines of force pass from *N* to *S* as shown by the arrows and as the loop revolves it pushes against and stretches these magnetic lines causing them to bend upward in front of the north pole and downward in front of the south pole as in Fig. 3.

As the bending continues the lines reach their limit of stretch and break, cutting across the conductor and generating a voltage which results in a current through the circuit. This flow of current is through the loop to d_1, resistor *r* and back to the loop by means of d_2, Fig 2.

It should be noted that the current is in such direction that the lines of force circling the wire, by virtue of this

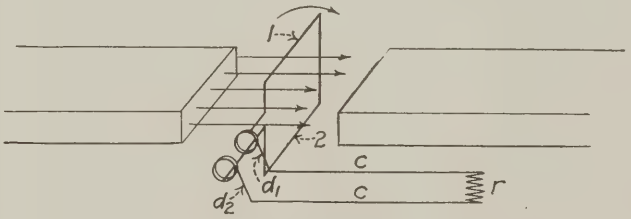


Fig. 4

current, agree with the bent portion of the magnetic lines emerging from the *N* pole and entering the *S* pole. This supplies us with an easy method of determining the direction in which the current will flow in the conductor when a conductor is passed across a magnetic pole in any given direction.

As the loop revolves it passes to the vertical position shown in Fig. 4 where it is seen to be moving parallel to the lines and, consequently, cutting none of them.

Therefore the e.m.f. generated at this point would be zero and no current would flow in the circuit.

Passing to the position of Fig. 5 we find the induced

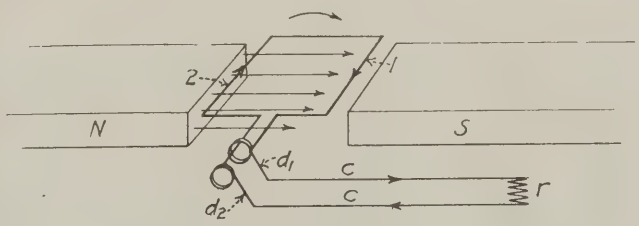


Fig. 5

current now flowing from d_2 through the resistor to d_1. The important thing to note here is that the direction of the current has reversed or alternated. Another quarter turn brings the loop to a position similar to that of Fig. 4 and the generated voltage is again zero. Another quarter turn completes the revolution in which the current has alternated and has passed through zero twice during this revolution.

Let us consider Fig. 6 which represents a circle divided into four quadrants, each of the four division marks being

designated with a letter conforming to the position of the loop in the above illustrations. Position *a* corresponds to that of the loop in Fig. 4; *b*, that in Fig. 5; *c*, that in Fig. 4, and *d*, that in Fig. 2, Fig. 4 representing the zero points as mentioned above.

The circle is made up of 360 equal divisions, called degrees, and each of the four sections *a-b*, *b-c*, *c-d* and *d-a* is equal to a quarter circle or 90 degrees.

Now let us take a line of any convenient length as Fig. 7 (a) and divide it into four equal parts. If the whole line represents 360 equal divisions then each of the four divisions will equal 90 degrees and if we letter the division marks as shown they will in turn represent the positions marked on the circle, Fig. 6. The distance from *a* to *c* is equivalent to the diameter of the circle and if we designate positions on the line as zero points *a* and *c* will be these points while *b* and *d*, which represent voltages other than zero must be placed outside the line. Therefore, let us mark two points above *b* and *d* to represent the voltage

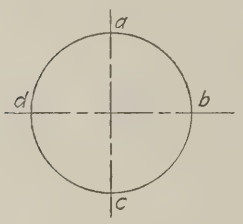


Fig. 6

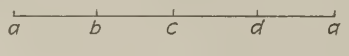


Fig. 7 (a)

generated at these two points. Upon joining these two points to the center and ends of the line as in Fig. 7 (b), we have a picture of the voltage resulting from the motion of the conductor from *a* to *a*.

However, the direction of the current in Fig. 5 was opposite to that in Fig. 2 so that to make our picture a true representation or photograph, as it were, of the generated voltage it will be necessary to arrange our little hills in such a manner as to take this feature into account.

The simplest way to do this would be to let the space above the zero line represent one direction of current flow through the loop and the space below the line, the current flow in the opposite direction. This changes the picture

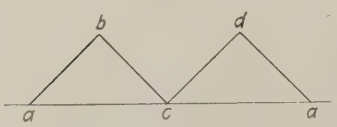


Fig. 7 (b)

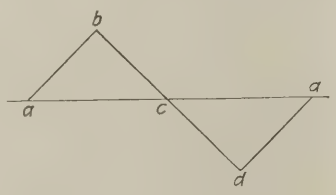


Fig. 7 (c)

from that of Fig. 7(b) to Fig. 7(c) which is a true representation of the passage of the loop around the circle with the exception of one little point that we shall now consider.

When conductor *1*, is in position *d* Fig. 2 it is cutting directly across the lines of force or at right angles to them, whereas in position *a* it is parallel with them. Between these two positions there are intermediate positions where the conductor is cutting lines at a rate between the maximum of *d* and the zero of *a*. This may be more readily grasped by a consideration of Fig. 8.

The arrows, Fig. 8(a) indicate the direction of motion of the conductor at the two extreme points and one intermediate point *i*.

Fig. 8(b) shows six lines of force taken from any section between the *N* and *S* poles. In passing from *1* to *2* or from *1* to *3* the conductor will have cut six lines of force but the distance moved in passing from *1* to *3* is greater than that from *1* to *2* so that if the conductor were to continue to move in the *1—2* direction it would cut more lines in a given space of time than it would if it were to move in the *1—3* direction. Thus, if it takes one second to pass from *1* to *2* the conductor will have cut six lines in that second, whereas it would only cut four lines if moving in the *1—3* direction.

We learned in our study of direct currents, that the

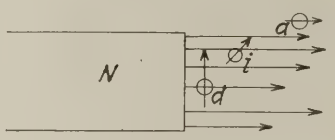
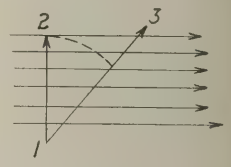


Fig. 8 (a)



(Fig. 8 (b)

voltage generated depended on the rate at which these lines were cut so that the voltage generated by a conductor moving in the *1—2* direction would be greater than that generated by one moving in the *1—3* direction.

Now consider Fig. 9(a) which shows various positions of the conductor in its passage around the circle. This is shown in pictorial form in Fig. 9(b). If we divide the voltage line in five parts as shown, from zero position *a*, to 10 volts *b*, the voltage is seen to vary from zero to two volts at a distance of nine degrees, four volts at eighteen degrees, six volts at twenty-seven degrees, etc., to ten

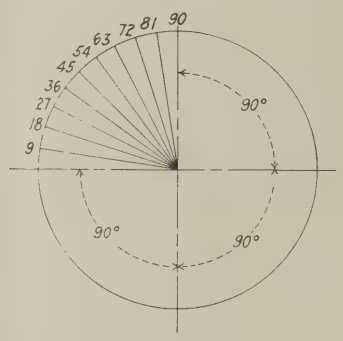
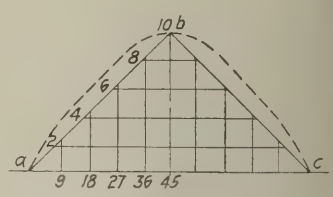


Fig. 9 (a)



(Fig. 9 (b)

volts at forty-five degrees which is the maximum voltage generated. The outline of this voltage curve is shown as a straight line, but this is not strictly true, and by means of the proper instruments it can be shown that the voltage varies somewhat from this straight line as signified by the dotted line Fig. 9(b) so that the voltage at nine degrees is three, at eighteen degrees five, etc., the maximum and the minimum values being ten and zero as before. This is the true picture of the wave of voltage generated and a complete picture of the revolution from *a* to *a* is shown in Fig. 10.

The wave is known as a sine wave of alternating e.m.f. or current as the case may be, because the current through the resistance Fig. 2 is assumed to follow the changes of voltage. This is seen to be true from a consideration of Ohm's law which states that current equals voltage di-

vided by resistance. The resistance has a constant value so that to obtain the curve for current flow it is only necessary to divide the instantaneous values of voltage by the constant resistance value. Thus, at the zero voltage point the value of the current is zero and at the maximum voltage point it is equal to ten divided by the resistance in ohms, which is assumed to be, in this case, two ohms, giving as the maximum current, five amperes.

One complete revolution such as illustrated above, is known as a cycle. A cycle may be defined as two alternations, one alternation being half of a complete sine wave as from *a* to *c* in Fig. 10. If the loop revolved ten times per second the number of cycles per second would be ten. The number of cycles per second is called the *frequency*. The most common present day frequencies are 25 and 60 cycles, the 60 cycle current being the more common of the two because of the fact that it is used for lighting in practically all parts of this country. In a two-pole machine it would require twenty-five revolutions per second for twenty five cycle current and sixty per second for sixty cycle current. This would result in a speed of 3,600 revolutions per minute to generate a sixty cycle current, but such a speed would be too high for a machine of any size such as a large lighting generator, so that it becomes necessary to use more than two poles to generate the 60 cycle current at a moderate speed.

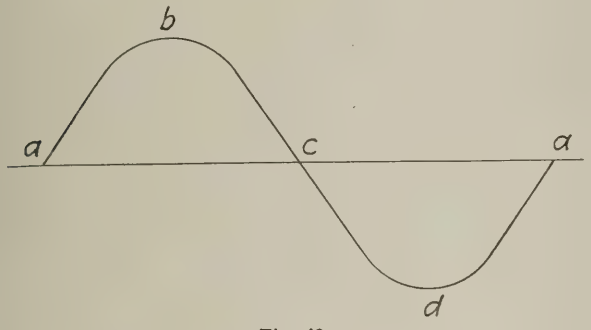


Fig. 10

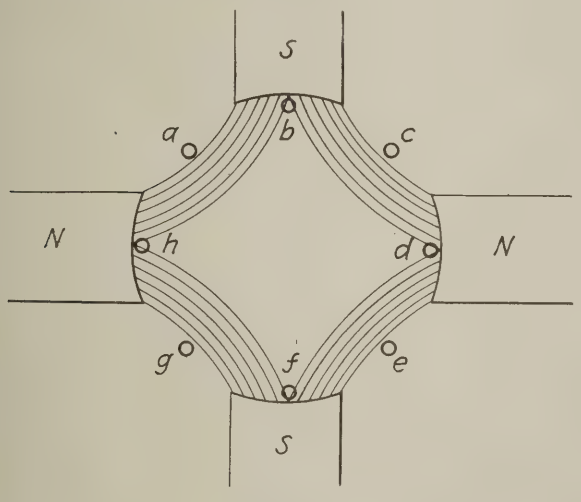


Fig. 11 (a)

Fig. 11(a) shows a four-pole generator, various positions of the moving conductor being indicated as *a-b-c-d-e-f-g-h-i*.

At *a* the conductor is moving parallel to the lines and the voltage generated in it is zero; at *b* it is maximum; at *c*, zero; at *d*, maximum; at *e*, zero; at *f*, maximum; at *g*, zero; at *h*, maximum, and at *a* again, zero. Thus the current has passed through zero four times and through maximum four times in one revolution.

Fig. 11(b) shows this in pictorial form and it is readily seen that the current has passed through two cycles in one revolution so that if it is desired to generate a 60 cycle current with this machine it would only be necessary to run the machine at a speed of 1,800 revolutions per minute which would be, in most cases, more suitable than to run at a speed of 3,600 revolutions.

In the same manner six poles would necessitate a speed of 1,200 r.p.m.; eight poles 900 r.p.m. and twelve poles 600 r.p.m. so that the generator or alternator, as it is called, might be designed to run at any convenient speed providing the proper number of poles are used.

As mentioned above, 60 cycle current is the more common for lighting and this is true because of the fact that the variation of voltage between zero and maximum produces a noticeable flicker of the lamps which is very objectionable if a frequency much less than 60 is used. Higher frequencies are not used to any great extent because of certain difficulties of transmission that will be taken up later on.

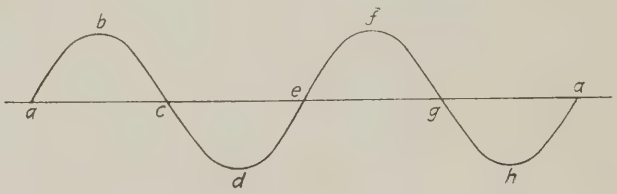


Fig. 11 (b)

Preliminary figures of the Department of Commerce for February, 1924, show that a total of $6,826,792 worth of electrical machinery apparatus and supplies were exported to foreign markets during that month, the value of February's export shipments during the same month of 1923 being $4,645,614. The excess over 1923 during the first two months of the year is thus extended to approximately $3,800,000. A tendency toward increased exports of appliance, rather than of heavy electrical apparatus, is noticeable so far during 1924.

Gilliams Service

One of the New Locomotives for Austria's Electrification

Locomotive Headlight Practice on the Erie

Large Amount of Equipment Maintained by Small Force at Busy Engine Terminal

IN a busy engine terminal, getting the most work in the shortest time usually calls for systematic arrangement of inspection and repairs. This is particularly true in the matter of headlight maintenance, and the electrical department of the Erie Railroad at Jersey City, N. J., have laid out a plan whereby each part of the work receives the attention of an expert in that particular line. It is not that headlight maintenance work is so extremely complex, but as with everything else that is done on a division of labor basis it has been found that the best results are obtained from having men assigned to the different parts of the work.

The gang of men who look after the headlight work is not large. Three men and a helper are employed on the day trick from 7:30 a. m. to 4 p. m., and on the second trick from 3:30 p. m. to 12 p. m., and only one on the night shift from 11:30 p. m. to 8 a. m. These men handle all of the headlight repairs on all of the locomotives running into the large city terminal. There is one additional man and helper who works in the back shop during the day, and these men are not strictly considered as a part of the maintenance force. Each morning the inspector goes out to look over the locomotives before they go out on their respective runs. He tries the generators out and sees that all of the lamps light properly. If he finds anything seriously wrong, he immediately reports the matter to the gang leader and steps are taken to make the necessary repairs as quickly as possible. All minor repairs are made by the inspector himself.

Another man gives his entire attention to the care of generators. He is an expert in this line, and does all of the overhauling of the machines and replaces parts wherever necessary. All of the oiling is done by a boy whose sole duty is to see that all turbines are properly lubricated.

As in many shops, compressed air is used for testing out generators that have been repaired. The air pressure available for this purpose on the Erie is approximately 95 lb. It is sufficient for the turbines to be driven at a speed which will cause the generator to develop enough voltage to light a number of lamps equivalent to the load which it must carry on the locomotive. The lamps on this test do not light up to full brilliancy, but the speed has been found sufficient for practically all tests that are required after the generator has been overhauled. The test board shown in one of the illustrations is used in trying out the generators, and the flexible air hose may also be seen connected to the intake of the turbine.

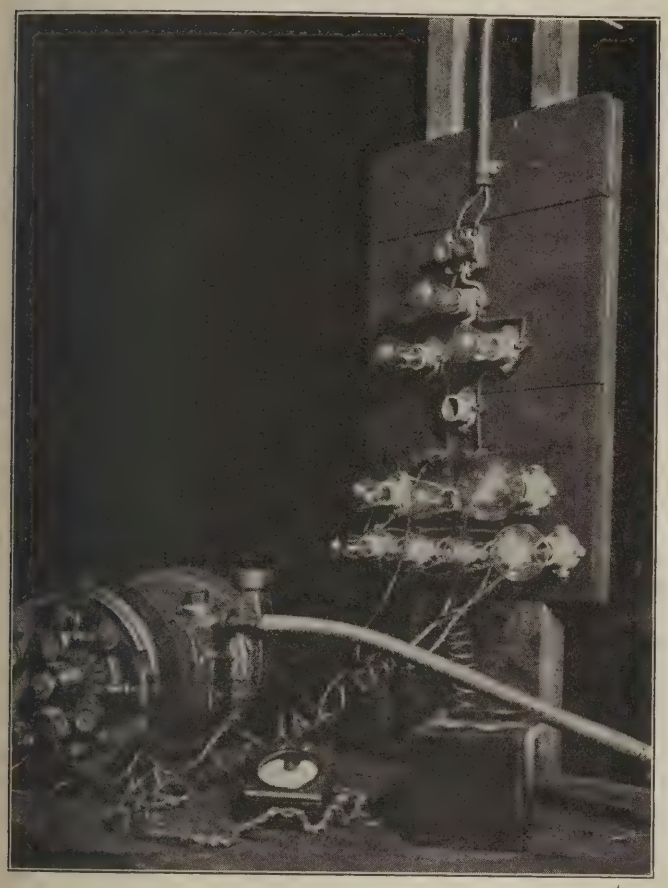
The lamp test board consists of two separate lamp arrangements. The lamps on the lower part of the board are the equivalent of those found on the locomotive including a 250-watt headlight. All of the lamps in these two lower rows are connected in parallel excepting a 100-watt lamp at the extreme right hand end of the lowest row, which is not connected with the others. At the upper part of the board conduit will be seen leading downward. This conduit carries 110-volt current for the three lamps arranged in a triangular formation at the center of the board. The uppermost lamp on the board is a 110-volt lamp and is used for illumination. The other two lamps to the right and left of the 110-volt lamp are 32-volt lamps. It will be seen from the wiring diagram that these lamps are connected in series with the vacant socket just below them. The threaded shell of this socket has been split so that it can be used for testing lamp filaments quickly by holding the lamp in the hand and inserting the base in the socket. In addition to the above testing arrangement, two leads are brought down

Store Room and Work Shop of Headlight Maintainers

from the terminals of the split socket, and these leads are used for testing armature or field coils and for any other purpose that a test circuit may be used. It will be seen that when the ends of these leads are brought together, the two 32-volt lamps on the test board will light up. The bank of lamps at the bottom of the board have no connection with the testing circuit but are merely placed there as a convenient load for generators under test. The practice of wiring on locomotives differs somewhat from that commonly used on other roads to the extent that the Erie does not use conduit in the cab wiring. In place of conduit and conduit fittings on the ceiling of the cab, wood molding is tacked on in which the wires are run, covered with wood capping. In keeping with this practice the lamp sockets are porcelain, some of them keyless. One lamp is located in front of the water and steam gages. The socket over the lubricator light is equipped with a key, as is also the socket immediately over the head of the engineer. This latter socket over the engineer is of the molded type suitable for fitting between two pieces of capping. On the locomotives which have separate compartments for the engineer and fireman, commonly known as the camel back type, there are two steam gages and consequently two lamps, one in each compart-

ment. In addition to these the fireman also has a light for the illumination of his compartment.

On the exterior of the locomotive, the wiring is run in the hand rail along the engineer's side of the cab to a point just back of the smokestack, where it enters a suitable conduit fitting from which it branches, part passing upward over the top of the locomotive to the marker lamp on the fireman's side, and part leading to the marker lamp on the engineer's side. Headlights are mounted in two ways on the Erie locomotives, either in front of the stack on top of the smokebox or on a special shelf ar-

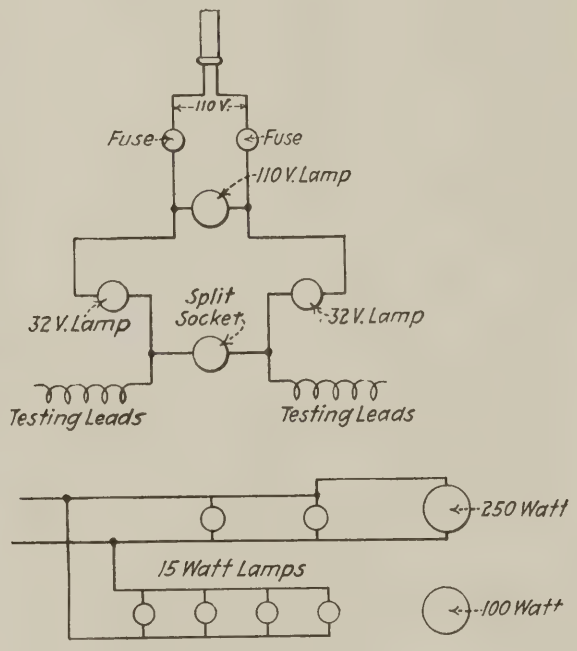


Turbo-Generator Being Tried Out Under Air Pressure

ranged in front of the smokebox in such a way that the center of the headlight is concentric with the center of the smokebox door. In this latter type of mounting, the headlight is supplied through a flexible armored conduit running from a junction box near the marker lamp on the fireman's side. The headlight generator is mounted in practically all cases on top of the boiler immediately in front of the whistle.

The wire used is No. 14 Okonite asbestos-covered wire. For the drop lights in the cab No. 18 heater cord is generally used, but in emergencies reinforced lamp cord has been used for this purpose. This practice has been found unsatisfactory, however, as the heat soon destroys the outside insulation. The usual routine of reporting trouble with the headlight equipment is as follows: If trouble develops during the run, the engineer makes out a proper ticket or slip and places it in a box in the shop where it is picked up by the gang leader, who immediately proceeds either to make the repairs necessary or to assign one of the other men to the work. When the work required on any particular locomotive is completed, the time and the material used are charged against that particular locomotive. The original ticket or slip is turned into the office of the shop foreman, where it is used as a basis for the headlight report which must be made up for the government. In connection with all of the work done, a complete record of the labor and material charges is kept in a book for that purpose. This book is kept by the gang workmen, and each man enters into it just what work has been done by him on any given trick. In case a job is too long to be finished by a man on one trick, it is taken up by other men coming on the next trick, and these men know exactly what has been accomplished by referring to the book which will tell them the state of the job when they come on duty. This book also includes the numbers of locomotives on which the turbo-generators have been oiled during the day. As there is but one man on the night trick, his duty is to make whatever repairs are necessary on the different locomotives going out during the night. He is practically a trouble man, and does little of the overhauling work such as is carried on by the day force.

There are about 310 trains which come into this terminal during the 24-hour period, and in the evening rush hours between 4:30 p. m. and 6:30 p. m. 57 trains leave



Wiring Diagram of Testing Board

the terminal. It should be mentioned that no work of winding armatures or field coils is performed by these men. All work of that nature is done in the repair shop at Dunmore, Pa. In view of the fact that none of the work is done in Jersey City, spare parts of the turbo-generators as well as spare headlight reflectors are carried on hand at all times.

An electrical method of gas analysis recently perfected makes possible the immediate detection of the change in composition of flue gases in a boiler plant, the recording of such changes throughout the day, and the manuel or automatic control of regulating apparatus in accordance with the gas composition. The new apparatus makes use of the fact that different gases have different rates of conducting heat.

The Status of Train Control on the Roads Today

Contracts for Installations Closed on Fifteen Roads While Tests Are Being Made on Nineteen Others

ALTHOUGH only 10 months remain for the completion of automatic train control on approximately 5,500 miles of road to comply with the Interstate Commerce Commission's order No. 13,413, only one road, the Chicago, Rock Island & Pacific, has received approval of its complete installation. In addition, the Chicago & Eastern Illinois, with 108 locomotives equipped and 105.4 miles of train control in service, is at this time making minor changes in the locomotive equipment and is thus practically in a position to meet the requirements of the order, while the Chesapeake & Ohio has 61 miles of train control in service, with 64 road locomotives.

These three roads are the pioneers in the permanent installation of train control and can hardly be considered as typical of the general condition on the other roads. Thus, among the remaining 46 roads mentioned in the order only 15 roads have definitely announced that contracts have been closed for the installation of train control over an entire engine district as required. Typical of these are the Norfolk & Western, the Atchison, Topeka & Santa Fe, and the Philadelphia & Reading, which have chosen the Union Switch & Signal Company's three-speed continuous induction device. On the Santa Fe, approximately 50 per cent of the wayside apparatus has been installed and seven locomotives are now being equipped. The Delaware, Lackawanna & Western and the Louisville & Nashville have contracted for the two-speed continuous device as manufactured by the same company. The Chicago, Indianapolis & Louisville has contracted for a 98 mile single track installation of the Sprague intermittent induction type of train control between Hammond, Ind., and Lafayette. The Southern Pacific reports that the National Safety Appliance Company's intermittent inductive device is to be installed on 75 miles of road between Oakland, Cal., and Tracy. The Galveston, Harrisburg & San Antonio has contracted for a 50.6 mile installation of the same type between Rosenberg, Tex., and Glidden.

The New York Central Lines have let contracts for materials for the construction of automatic train control apparatus for their five roads named in the first order of the I. C. C., namely: Boston & Albany, between Springfield, Mass., and Albany, N. Y.; Michigan Central, between Detroit, Mich., and Jackson; Big Four, between Indianapolis, Ind., and Mattoon, Ill.; Pittsburgh & Lake Erie, between Pittsburgh, Pa., and Youngstown, Ohio, and the New York Central between Albany, N. Y., and Syracuse. Contracts have been let for the first three named roads to the General Railway Signal Company, the fourth to the Union Switch & Signal Company, and the fifth to the Sprague Safety Control & Signal Corporation. The installation will be done by railroad company forces.

Test Installations

Sixteen railroads report road tests of train control devices. Perhaps the most extensive test installation made is that put in service by the Pennsylvania Railroad on 51 miles of road between Sunbury, Pa., and Lewiston. This installation uses the Union Switch & Signal Company's three-speed continuous induction system. Twenty locomotives have been fitted up with the engine equipment. The New York, New Haven & Hartford has in service a 10-mile test installation of the Union Switch & Signal Company's three-speed continuous induction apparatus between Cedar Hill, Conn., and Wallingford, with one locomotive equipped.

A test installation of the intermittent induction system as developed by the National Safety Appliance Company has been in service on 5 miles of single track on the St. Louis-San Francisco between Nichols Junction, Mo., and Brookline since June, 1923, on which there are 8 locomotives now equipped. This same system of train control is being tested on the Chicago & Alton, which has made an installation on 14 miles of double track near Bloomington, Ill. There are 4 locomotives equipped and operating over this territory.

The Chicago & North Western has been conducting a road test on the General Railway Signal Company's intermittent induction train control system, with tapered speed control. This test installation is in service between West Chicago, Ill., and Elgin, a distance of 16 miles. The Buffalo, Rochester & Pittsburgh has also been testing the General Railway Signal Company's intermittent induction system, with the tapered speed control on 16 miles of road. Four locomotives are equipped for test purposes. The Baltimore & Ohio has made a test installation of the General Railway Signal Company's intermittent inductive system. This installation consists of three magnet groups and one locomotive equipped with the engine device.

The Chicago, Burlington & Quincy put in a test installation on 8 miles of road, using the Federal Signal Company's continuous type of train control. One engine was equipped and the material for an additional locomotive is practically completed. The Delaware & Hudson has been making a test of the Federal Signal Company's system using one locomotive over 3.5 miles of road.

The Union Pacific has in service a test installation including three systems, the Union, the Miller and the National. One locomotive is equipped with the three devices, the wayside equipment of the systems being installed on different track sections.

Numerous road tests for short periods of time have been made by several roads among which is the Great Northern test of the Miller and the National systems. The Cleveland, Cincinnati, Chicago & St. Louis has made tests of the Indiana Equipment Company's device, while the Webb, and the Train Control Corporation of America (Clifford) devices are under test on the Erie railroad. Numerous other tests not mentioned in this article have been made. However, the list as shown in the accompanying table includes those installations and tests as reported by the railroads to the Commission.

On January 14, the Interstate Commerce Commission added to its original train control order a list of 45 additional railroads requiring that these roads make installations of automatic train control over one passenger loco-

STATUS OF TRAIN CONTROL INSTALLATIONS UNDER ORDER OF JUNE, 1922

Railroad	Miles of Road Operated by System x	Number of Locomotives on System y	Present Signaling in Territory Selected: Miles of Track Equipped with Automatics	Present Signaling in Territory Selected: Number of Interlockings	Average Number of Trains Each Way Daily	Installation Under First Order to Include: Selected Territory Covers: From	To	Miles of Road: Single	Miles of Road: Double	Miles of Track	Locomotives To Be Equipped: Passenger	Locomotives To Be Equipped: Freight	Test Installations: Train Control Selected	Test Installations: Type of Train Control	Test Installations: Miles
A. T. & S. F.	8,966	2,159	.....	6	30	Chicago, Ill.	Shopton, Iowa	...	234.6	469.2	41	84	U. S. & S.	Induction	
A. C. L.	4,858	881	229.6	..	..	Acca, Va.	So. Rocky Mt., N.C.	...	114.6	229.3	13	20, 11Y		G. R. S.	14
B. & O.	5,212	2,558	72.6	5	50	Baltimore, Md.	Washington, D. C.	...	36.3	72.6	34	95		G. R. S.	9
*B. & A.	394	360	202	..	..	Albany, N. Y.	Springfield	...	101	202	41; 11 P. & F.	95	G. R. S.		
*B. & M.	2,512	1,134	211.2	..	..	Boston	Greenfield	...	105.6	211.2	40	93		U. S. & S.	13.7
B. R. & P.	590	290	106	1	25	Rochester, N. Y.	Ashford	82	12	106	14	79		G. R. S.	15
C. R. R. of N. J.	685	573	27.7	..	30	Red Bank, N. J.	Winslow Jct.	65.9	...	65.9	37; 48 P. & F.	5			
*C. & O.	2,558	947	61	2	..	Gordonville	Staunton	61	...	61	29	35	American	Ramp.	
C. & A.	1,052	341	227.6	12	26	Chicago, Ill.	Bloomington	51.2	101	253.2	14	32		National	14
C. & E. I.	945	347	210.8	17	30	Yard Center, Ill.	Danville	...	105.4	210.8	57	50	Miller	Ramp.	
*C. & E.	.....	.....	253.2	..	..	Marion, Ohio	Huntington, Ind.	...	126.6	253.2	6	24 E.J.&E. 42			
C. & N. W.	8,462	2,092	298	2	20	Boone, Iowa	Council Bluffs	...	149	298	62	60		G. R. S.	16
*C. B. & Q.	9,393	1,929	171.1	6	..	Creston, Iowa	Omaha, Neb.	44.3	63.4	171.1	12; 11 P. & F.	32		Federal	12
*C. I. & L.	654	158	84	3	..	Hammond, Ind.	La Fayette, Ind.	97	...	97	15	15	Sprague	Induction	Sprague 10
*C. M. & St. P.	10,601	2,034	215.6	6	..	Bridge Switch	Hastings	...	108.1	215.6	21	29			
C. R. I. & P.	8,123	1,633	330.8	9	24	Blue Island, Ill.	Rock Island	165.4	165.4	330.8	39	63	Regan	Ramp.	
C. St. P. M. & O.	1,749	396	235	..	8–12	St. James, Minn.	Le Mars, Iowa	122.6	...	122.6	30	73			
*C. C. C. & St. L.	2,407	898	114	..	..	Indianapolis	Mattoon	56.3	72	200	22	48	G. R. S.		
*D. & H.	873	490	113	..	..	Whitehall	Rouses Point	113	...	113	12	51		Federal	
D. L. & W.	981	762	292	..	25	Elmira	Buffalo	...	146	292	10	65	U. S. & S.	Induction	
*Erie	2,447	1,549	208.4	..	..	Port Jervis	Susquehanna	...	104.2	208.4	12	64		Webb; Clifford	
G. H. & S. A.	1,400	326	210	..	12	San Antonio	Houston	200	10	220	58	91	National		51
G. N.	8,266	1,423	121	..	9	Minot, N. D.	Williston	121	...	121	8	26		Miller; National	
I. C.	4,709	1,672	249.4	..	29	Champaign	Centralia	...	124.7	249.4	11	46	U. S. & S.	Induction	
*K. C. S.	836	183	...	7	..	Grandview, Kan.	Pittsburgh	104	...	104	11	36			
*L. V.	1,335	1,019	...	..	..	Newark, N. J.	Easton, Pa.	24.8	6.2	168.4	30	120	G. R. S.	Induction	
L. I.	395	165	5	3	59	Long Island	Port Washington	10	9.5	29	..	4			
L. & N.	5,039	1,306	165	..	25	Corbin, Ky.	Etowah	165	...	165	9	22	U. S. & S.	Induction	
*M. C.	1,862	806	158	..	..	Detroit	Jackson	...	79	158	22	28	G. R. S.		
*Mo. P.	7,179	1,169	...	5	..	Kansas City	Council Grove	146	...	146	6	12	National		13.9
*N. Y. C.	5,710	3,467	578.69	..	..	Albany	Syracuse	...	10.5; 138F	581.8	104	216	Sprague	Induction	
*N. Y. C. & St. L.	523	285	124	2	18	Chicago	Ft. Wayne	128.4	14.2	156.8	7	29	U. S. & S.	Induction	
*N. Y. N. H. & H.	1,948	1,236	...	..	..	Air Line Jct.	Springfield	...	62	124	66 P. & F.	..		U. S. & S.; G. R. S.	10.5
N. & W.	2,238	1,097	...	..	10	Shenandoah, Va.	Hagerstown, Md.	107	...	107	10	40	U. S. & S.	Induction	
N. P.	6,656	1,439	109.3	..	13	Mandan, N. D.	Dickinson	109.3	...	109.3	9	20			
*O. W. R. & N.	2,238	314	84	1	..	East Portland	The Dalles	84	...	84	8	12			
Penna	10,534	7,447	14.5	21	49	Baltimore	Harrisburg	0.19	83.01	166.2	64	123			
P. C. C. & St. L.	.....	.....	35.53	..	..	Indianapolis	Columbus	53.5	134	345.5	25	114		U. S. & S.	50
W. J. & S. S.	.....	.....	116.8	9	78	Camden, N. J.	Atlantic City	...	58.4	116.8	102	44			
P. & R.	1,127	1,095	111	..	65	Camden	Atlantic City	...	55.5	111	41	9	U. S. & S.	Induction	
*P. & L. E.	231	324	223.9	14	..	Pittsburgh	Youngstown	...	18.87; 46.9T	223.9	20	50	U. S. & S.	Induction	
*P. M.	2,213	448	...	4	..	Alex, Ohio	Romulus, Mich.	37	...	37	18	47	U. S. & S.	Induction	
*R. F. & P.	119	91	203.2	7	..	Richmond	A. F. Tower	...	101.6	203.2	53	2			
*St. L.-S. F.	4,769	937	47.7	..	..	Springfield	Sapulpa	195.2	4	203.2	20	40		National	
*S. P.	7,117	1,499	99	..	..	Oakland	Tracy	51	24	99	45	25	National		
*Southern	8,310	2,212	306	1	..	Spencer, N. C.	Greenville, S. C.	...	153	306	22	37			
C. N. O. & T. P.	.....	.....	...	22	..	Ludlow, Ky.	Somerset	78	78.5	235	14	66		G. R. S.	35.2
*U. P.	3,709	1,008	...	7	..	Sydney, Neb.	Cheyenne, Wyo.	...	102	204	40	60		National; Union; Miller	
*W. M.	702	302	80	..	..	Elkins, W. Va.	Thomas	35.1	...	35.1	2	12			

* As reported to the I. C. C.
x, y; As given in official pocket list.

motive division between specified limits. Forty-seven of the original 49 railroads were also ordered to make further installations over another passenger locomotive division in addition to the first division ordered to be installed on June 13, 1922. The railroads have asked for a rehearing on train control and asked that the second order be annulled. Inasmuch as the second order has been of such recent date the new roads have not had the opportunity as yet to decide definitely what is to be done on their lines as it will be necessary for each railroad to study the local traffic conditions peculiar to itself. For this reason the information given in this article is based largely upon the 49 roads included in the original order.

Strathcona Memorial Fellowship in Transportation

A STRATHCONA Memorial Fellowship in Transportation, of one thousand dollars, is offered annually for advanced work in transportation, with special reference to the construction, equipment and operation of railroads, the problems connected with the efficient transportation of passengers and freight and the financial and legislative questions involved. The holder of the Fellowship must be a man who has obtained his first degree from an institution of high standing. In making the award, preference is given in accordance with the will of Lord Strathcona to such persons or to sons of such persons as have been, for at least two years, connected in some manner with the railways of the Northwest.

Applications for this Fellowship should be addressed to the Dean of the Graduate School of Yale University, New Haven, Conn., before May 1, on blanks which may be obtained from the Dean, and should be accompanied by—

1. A statement of the applicant's education and practical experience.
2. A statement of the particular field of interest to the applicant and his reasons and purposes for desiring the Fellowship.
3. Letters of recommendation.
4. Reprints of articles or publications by the applicant.

Direct Current Transformer

A DEVICE which is called a direct-current transformer is described in literature sent out recently by the Gisholt Machine Company, Madison, Wis. The transformer is, in fact, a specie of potentiometer and its purpose, as the name implies, is to provide small quantities of direct current at a low voltage from regular direct-current supply circuits.

When there is no load on the secondary, the current consumption from the supply circuit is only 60 miliamperes. The maximum capacity of the transformer is five amperes. Pilot lamps are used to indicate conditions in the circuit. The device is used for elevator signals, clock systems, time stamps, bells, buzzers and so forth. It has been approved by the Underwriters' Laboratories and about 200 are in use in the direct-current district of Chicago.

To serve as a standard of radio frequency the Bureau of Standards has two specially constructed wavemeters covering the frequencies from 18 to 4,600 kilocycles per second. These standard wavemeters are used in calibrating wavemeters belonging to the Radio Inspection Service, manufacturers, colleges or others in need of standards of frequency, in radio measurements and in adjusting the set used to transmit standard frequency signals.

Each wavemeter consists of a variable air condenser of special design, four fixed mica condensers, a number of interchangeable inductors or coils, and a resonance indicating device. The majority of the inductors are wound with high-frequency cable in a single layer upon a skeleton frame of bakelite.

The wavemeter is tuned by varying the air condenser and obtaining the maximum deflection of an indicating instrument which is connected to two turns of wire and loosely coupled to the inductor in the wavemeter circuit. Either of two instruments may be used, a thermogalvanometer or a.d.c. milliameter and crystal detector.

The C. N. R. Continental Limited in British Columbia

Report of A. R. E. A. Committee on Electricity

Overhead Transmission and Distribution Line Construction Among the More Important Features Presented

AT the 25th annual convention of the American Railway Engineering Association, recently held in Chicago, the Committee on Electricity presented some interesting specifications in connection with the construction of overhead electric supply lines for railroad use on railroad property. The following is an abstract of the report which was presented:

General

Scope.—These specifications describe the standard practices for the construction of electric power transmission and distribution pole lines, exclusive of overhead contact wires.

Location.—In laying out lines consideration shall be given to permanency of location and to avoidance of railroad and highway crossings and unnecessary corners.

Lines should ordinarily be located as close to the edge of the right-of-way as will leave room for the proper use of side guys. Where, however, the right-of-way is exceptionally wide the line need not be placed along the extreme edge, but should preferably be located a sufficient distance from the nearest track to provide ample clearance in the case of overturning.

The greatest practicable separation should be maintained from all communication lines (telegraph, telephone and signal). In general it is desirable to place supply lines on the opposite side of the right-of-way from communication lines.

Lines should be so located as to permit an unobstructed view of signals, signs, etc.

Relative Levels.—In general, circuits shall be arranged in the order of their operating voltages, conductors of the greatest voltage occupying the highest position, with the exception of trolley feeders which may occupy the lowest position.

Inverted Levels.—Where circuits of lower voltage must of necessity occupy upper positions, their mechanical construction shall equal that required for circuits of higher voltage below them.

Fire Hazard.—Poles shall be located as far as practicable from inflammable structures. The space around poles should be free from underbrush, grass or other inflammable material.

Tree Trimming.—Where trees exist near the conductors they shall be trimmed so that neither the movement of the trees nor the swing or sag of the conductors will cause contact. Overhanging or decayed trees endangering the line should be removed.

Protective Coating.—Steel poles, towers or supporting structures, bolts, nuts, washers, guys, anchor rods and similar parts of material subject to rapid corrosion under prevailing conditions shall be protected by galvanizing, painting or other treatment which will effectively retard corrosion. Parts shall be thoroughly cleaned at the shop before treatment.

Material to be galvanized shall be drilled or punched before galvanizing.

An approved paint shall be used and painting shall consist of one shop coat on contact surfaces before assembling, one complete shop coat and one or more complete field coats after erection. Before painting in the field, the surface shall be thoroughly cleaned, and worn or defaced spots, field rivets and bolts shall be touched up. No painting shall be done on frosted or wet surfaces.

Guards and Warning Signs.—Supporting structures and guys exposed to traffic or damage which will materially affect their strength shall be protected by suitable guards, preferably painted white. Warning signs shall be provided where local conditions require their use.

Types of Construction.—These specifications provide for two types of construction, namely, Type I and Type II. These types differ only in the allowable unit stresses.

Type I Construction.—Type I construction shall be used for lines where the voltage of conductors exceeds 750 volts (440 volts to neutral or ground) and located as follows:

(a) Paralleling railroad tracks or their associated wire lines and within fouling or striking distance in case of overturning.

(b) Adjacent to highways.

(c) At station grounds.

Type II Construction.—Type II construction may be used for lines of any voltage where located beyond fouling or striking distance from the railroad tracks or their associated wire lines, and for any lines wherever located having a voltage between conductors of less than 750 volts (440 volts to neutral or ground).

Construction at Railroad Crossings and Crossings of Communication Lines.—At railroad crossings and crossings of communication lines, construction, inclusive of clearances, should conform to the Railroad Specifications for Electric Light, Power Supply and Trolley Lines Crossing Railways.

Clearances

Clearance from Tracks.—Poles shall preferably be set so that the minimum horizontal clearance of any pole, guy or other attachment will be 10 ft. from the gage line of the nearest main track rail. In special cases poles may be set and guys placed with a minimum horizontal clearance of 8 ft., provided that the lowest conductor or similar attachment to a pole with a horizontal clearance of less than 8 ft. shall be, at 60 deg. F., not less than the following height above the top of rail:

Conductors, 0 volts to 750 volts.....	27 ft.	
Conductors, 750 volts to 7,500 volts....	28 ft.	
Conductors over 7,500 volts.....	28 ft.	plus 0.1 ft. for 1,000 volts in excess of 7,500 volts with a minimum of 30 ft.

At sidings, poles may be set at a minimum horizontal clearance of 7 ft. from the gage line of the nearest track rail, provided the conductors and attachments having a horizontal clearance of less than 7 ft. from the nearest track rail conform in height to the values given in the preceding paragraph.

NOTE.—In exceptional cases where the above horizontal clearances cannot be secured, poles and attachments may be placed closer to the nearest track rail than specified above, provided they are outside the standard clearance diagram of the railroad, and provided the conductor clearances are not less than specified in the first paragraph of this section.

Clearance from Ground.—The minimum clearance from ground, under conditions of maximum sag shall be not less than specified in the following table:

TABLE I

Nature of crossing	Clearance for the several groups: Guys, spans, lightning protection wires, messengers, lines less than 750 volts to ground	Clearance for the several groups: 750 volts up to 7,500 volts to ground
Crossing or along streets or alleys in urban districts or crossing streets or roads in rural districts	18 ft.	20 ft.
Crossings above spaces or ways accessible to pedestrians only	12 ft.	15 ft.
Above ground of right-of-way	10 ft.	13 ft.

For voltages in excess of 7,500 volts add to the above clearance 0.1 ft. per 1,000 volts in excess of 7,500 volts.

Horizontal Clearances from Paralleling Lines.—Where practicable, the horizontal clearance from a paralleling line of another class shall be not less than the height of poles of the taller line or the lines shall be on the opposite sides of the right-of-way.

In case such separation cannot be obtained, the circuits of the higher voltage class shall be attached to their supporting structures at a higher level than those of the associated line.

Clearance from Trees.—A clearance of at least 4 ft. from trees and underbrush shall, where practicable, be provided for all wires and cables. The clearance shall not be less than 2 ft.

Clearance from Buildings.—Conductors should be so arranged and maintained as to hamper or delay firemen as little as possible in the performance of their duties.

Conductors, unless in grounded metal conduit or grounded metal sheathed cables, shall have a clearance from the face of buildings of not less than 6 ft. plus 0.1 ft. for each 1,000 volts in excess of 7,500 volts.

Conductors, unless in grounded metal conduit or grounded metal sheathed cables, crossing over buildings should preferably have a minimum clearance of 10 ft., and crossing over bridges 8 ft. plus 0.1 ft. for each 1,000 volts in excess of 7,500 volts, in addition to the requirements mentioned in paragraph entitled "Clearance from ground."

Clearance from Bridge Abutments.—The clearance between any conductor and the face of abutment shall be not less than 3 ft. for steel bridges or other bridges with accessible wing walls, or 1 ft. for brick, stone or concrete bridges with inaccessible wing walls or without wing walls, but in no case shall the clearance between any conductor and the face of an abutment be less than that required in clearance for Bridge Structures except that conductors as covered in the following paragraph may be attached directly to the face of an abutment not less than 2 ft. below the elevation of the bridge structure and they shall provide clearance for pedestrians, vehicles, etc., as may be required.

Insulated conductors beneath bridges should preferably be installed in metal conduit or armor or metal sheath cable. The conduit or messenger (if any) and the armor or metal sheath of the cable shall not be in metallic contact with the bridge structure and shall be permanently and effectively grounded. The insulation of such conductors shall be capable of withstanding at least twice the normal line voltage between any two conductors or between any conductor and the sheath or armor. If such conductors are attached to the bridge supports they shall be supported in an approved manner with insulator pins permanently and effectively grounded independently of the bridge structure. The bridge structure itself shall be permanently and effectively grounded.

Clearance from Bridge Structures.—The clearance between any conductor attached to the bridge in open construction and any portion of the structure shall preferably be not less than the following:

TABLE II

Nominal Operating Voltages: Exceeding	Nominal Operating Voltages: Not Exceeding	Clearances
.....	2,500	1 ft.
2,500	5,000	2 ft.
5,000	7,000	3 ft.
7,000	14,000	5 ft.
14,000	27,000	7½ ft.
27,000	35,000	9 ft.
35,000	.....	12 ft.

Where conductors in open construction are not attached to the structure, the minimum clearance in any direction from the bridge structure shall be 3 ft. for voltages not exceeding 7,500 volts. Such clearances of conductors of greater voltages shall conform to the above table.

Separation of Conductors at Supports.—(a) The minimum separation, in any direction, at the point of support for conductors of different potential supported on insulators which are not free to swing shall be not less than the sum of the following quantities:

One inch for each 30 ft. of the longer adjacent span.

One inch for each foot of normal apparent sag (60 deg. Fahr. and no wind).

Four-tenth inch for each 1,000 volts in excess of 7,500 volts between conductors.

(b) In no case shall the separation be less than that shown in the following table:

TABLE III

Voltage Between Conductors: Exceeding	Voltage Between Conductors: Not Exceeding	Separation
0	7,500	12 in.
7,500	14,000	20 in.
14,000	27,000	30 in.
27,000	35,000	36 in.
35,000	47,000	45 in.
47,000	70,000	60 in.
70,000	60 plus 0.6 inch for each 1,000 volts in excess of 70,000 volts	

NOTE—Direct current railway feeders 4/0 or larger not exceeding 750 volts may have 6 in. separation.

(c) Where supported by insulators of the suspension type, the separation of conductors shall be increased so that one string of insulators may swing transversely through an angle of 45 degrees from the vertical position, the other remaining stationary, without decreasing the separation in Paragraphs (a) and (b) above, measured at the point of conductor attachments.

NOTE 1.—In long spans or where there is a wide disparity in size of conductors, the clearances given above may be insufficient to give proper separation in the center of the span and the clearances shall be increased.

NOTE 2.—The separations specified above do not apply to pole wiring.

Clearance of Conductors from Supports, Guy Wires, Trolley Span Wires and Conductors of the Same or Other Circuits on the Same Supports.—(a) The clearance of conductors from the surfaces of poles or towers shall be not less than a 5 in. plus ¼ in. for each 1,000 volts in excess of 7,500 volts, except that conductors carrying not more than 300 volts may be carried on one side of the pole on suitable metal brackets or racks with a clearance of not less than 3 in.

(b) The clearance of conductors from surfaces of supports (except surfaces of poles or towers) or from vertical or lateral conductors of the same circuits shall be not

less than 3 in. plus ¼ in. for each 1,000 volts in excess of 7,500 volts.

(c) The clearance of conductors from guy wires and trolley span wires or from vertical or lateral conductors of other circuits shall be not less than 6 in. plus four-tenths inch for each 1,000 volts in excess of 7,500 volts.

NOTE.—Where a conductor is supported by the span wire this clearance is not required.

(d) Where suspension type insulators are used and are free to swing, the clearance requirements of (a), (b) and (c) above shall be maintained with a transverse insulator swing of 45 deg. measured from the vertical position.

(e) The clearance of conductors from guy, trolley span, suspension or lightning protection wires paralleling the line, shall be not less than the separation required between any two of the line conductors, with which such guy, trolley span, suspension or lightning protection wire is immediately associated.

Side Clearance of Conductors of One Line from the Supports of Another Line.—Where conductors of one line are carried near a supporting structure of a second line, and are not attached thereto, the clearance between the conductors of the first line and any part of the supporting structures of the second line shall be not less than three feet at 60 deg. F. and no wind.

In no case shall this clearance be less than the values in Table III plus 2 ft. increased by 2/10 ft. for each 10 ft. of the distance from the nearest support of the lower line to a point in the lower line nearest the nearer support of the upper line.

Grading of Lines

Grading.—In general a line should follow the contour of the ground so that poles may be uniform in length. Where the contour of the ground changes abruptly or where it is necessary to change the level of the line to clear trees, buildings or other obstructions or at crossings, the lines shall be graded so as to avoid upward pulls. If it is impossible to avoid heavy upward pulls special construction shall be used.

Loading

General.—In arriving at an assumed loading, the experience of the railroad concerned, Weather Bureau wind velocity records, local records of ice coating, direction of the line, direction of prevailing winds, shelter and such other modifying features may be considered.

In the calculation of stresses no reduction in assumed load shall be made on account of deformation, deflection or displacement of any part of the supporting structure, including the suspension insulators.

Heavy Loading on Wires and Cables.—Heavy loading on wires and cables shall be the weight of the wire or cable plus the weight of a coating of ice ½ in. in radial thickness combined with a transverse horizontal wind pressure of 8 lb. per sq. ft. on the projected area of the ice-covered wire of cable at 0 deg. F.

Medium Loading on Wires and Cables.—Medium loading on wires and cables shall be the weight of the wire or cable plus the weight of a coating of ice ¼ in. in radial thickness combined with a transverse horizontal wind pressure of 10 lb. per sq. ft. on the projected area of the ice-covered wire or cable at 15 deg. F.

NOTE.—The weight of ice shall be assumed as 57 lb. per cu. ft. (0.033 lb. per cu. in.).

Light Loading on Wires and Cables.—Light loading on wires and cables shall be the weight of the wire or cable combined with a transverse horizontal wind pressure of 15 lb. per sq. ft. on the projected area of the wire or cable at 32 deg. F.

Loading on Supports.—On supporting structures having cylindrical surfaces, the wind pressure per sq. ft. for heavy, medium and light loading shall be the same as that specified in the preceding three paragraphs, respectively. On flat surfaces, these wind pressures shall be increased by 60 per cent. On latticed structures the wind pressure shall be taken on the actual exposed area of one face, increased by 50 per cent. The total thus obtained for latticed structures need not be considered in excess of that for a solid structure of the same outside dimensions. In calculating the wind pressure, ice covering on supporting structures may be neglected.

Vertical.—The vertical loads upon poles, towers, foundations, crossarms, pins, insulators and conductor attachments shall be their own weight plus the superimposed weight which they support, including the wires and cables, ice coated where specified, together with the effect of any difference in elevation of supports.

Transverse.—The transverse loading on poles, towers, foundations, crossarms, pins, insulators and conductor attachments shall be that due to the horizontal wind pressure specified for the district on the conductors, ice covered where specified, the wind pressure on the structures themselves as specified, together with any transverse load due to a turn or angle in the line.

Longitudinal.—On anchor or dead end structures the longitudinal loading on poles, towers, foundations, crossarms, pins, insulators and conductor attachments shall be the total pull of all wires and cables supported, the pull in each being taken as the tension therein when loaded as specified for the districts.

Where there is an unbalanced load due to any cause such as an unsymmetrical arrangement of conductors which will cause torsional stresses in excess of the stresses due to the longitudinal and transverse load specified, such conditions shall be taken into consideration and adequate provision made for them.

On intermediate poles, towers, foundations, crossarms, pins, insulators and conductor attachments the longitudinal loading requirement may be neglected, provided the complete structure will meet the transverse strength requirements if applied in any direction.

NOTE.—In the case of flexible structures commonly known as A frames the above requirements may be considered as being met longitudinally if all structures between anchor structures are connected by an overhead ground wire attached to each structure and capable of withstanding, without exceeding the allowable unit stress, a longitudinal loading equal to the transverse loading.

The latest list of stations broadcasting weather reports, music concerts and lectures shows 95 broadcasting stations connected with universities, colleges, and other schools. The same directory lists 46 newspapers or publishing houses which have their broadcasting stations, while 20 churches are shown in the lists. This does not, however, include a number of churches whose services are broadcasted through some other station. Two states have broadcasting stations for their bureaus of markets, while nine municipalities, chambers of commerce or boards of trade have broadcasting stations, part of these being used for city police forces.

Reversed Phase Causes Subnormal Motor Speed

By V. T. Kropidlowski

During a time the writer was employed in the steel industry in the northern part of Minnesota, he was called to one of the mining localities to correct an induction motor trouble. It was a three-phase 440-volt, six-pole, 60-cycle squirrel cage induction motor. Being a six-pole 60-cycle motor, its no load speed should be 1,200 r.p.m. By applying a speed indicator its speed would vary between 400 and 500 r.p.m. The rotor had no loose end connections and it did not develop a high voltage, nor did it heat. The writer asked if anything had been done to the primary winding and was told that on account of the motor burning out it had just come from the main repair shop where most likely it had received some new winding. The writer then removed one of the heads so as to get at the end connections. He connected the primary winding to his automobile storage battery, connecting two leads to

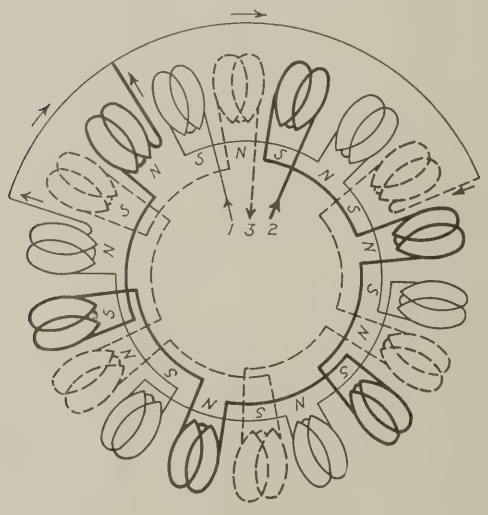


Fig. 1

the positive side of the battery and one to the negative. Connected in this manner, a properly connected three-phase motor should be magnetized in such a way that three consecutive poles would be of the same polarity and the next three of opposite polarity, forming, in the case of a 1,200 r.p.m. 60-cycle motor, six groups of alternately positive and negative poles. In this motor, however, when testing with a small pocket compass, the consecutive poles were alternately north and south, as per Fig. 1. This indicated that one of the phase windings was reversed. The three leads were then connected to the positive lug of the storage battery and the star connection (it being a star connected winding) to the negative lug. Connected thus, the polarities of adjacent poles should be opposite, but in this motor three consecutive poles had similar polarities while the next three had the opposite polarity, etc. Since the only polarities that could be reversed to bring about the proper arrangement were those corresponding to phase No. 3, Fig. 2, it indicated that this

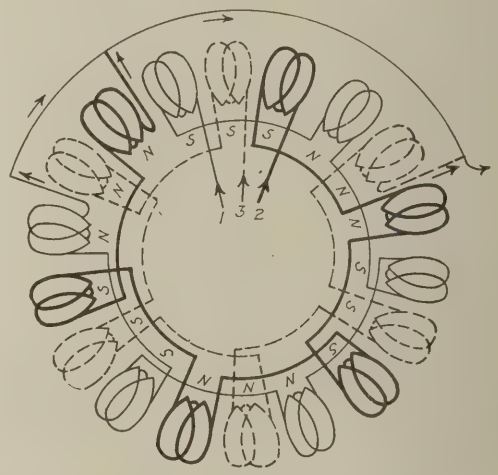


Fig. 2

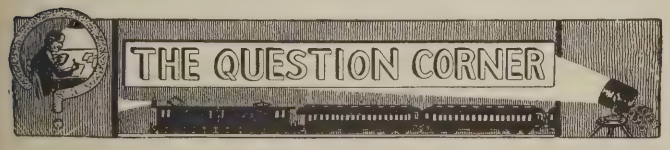
phase was reversed; that is, the terminal which should have been a lead was connected to the star point and vice versa. When the end connections of phase No. 3 had been reversed, as shown in Fig. 3 and the winding connected to the storage battery in such a way that current flowed into leads 1 and 2 and out of lead 3, see Fig. 3, the small pocket compass showed that the poles were properly magnetized, that is, three consecutive poles being of the same polarity, forming six groups of positive and negative pole regions. The direction of the currents in the three phases, due to being connected to the battery in this manner is representative of the instantaneous values of the currents surging through the primary winding of a three-phase motor when properly connected to a three-phase supply circuit. The magnetism in each of the three similar poles swells to its maximum strength consecutively during a half cycle, then the polarity is changed in all three poles again during the next half cycle and the swelling of the magnetism is repeated, and so on. This is what causes the rotating field and drags the rotor around at a speed corresponding to the number of such groups of

pole regions and to the number of cycles of the supply circuit. When one of the phases, or windings, of a three-phase motor is reversed, however, there is a period during each half cycle when the swelling of the magnetic lines in the consecutive poles does not progress, but merely pulsates, during which period the rotor receives no impulse to rotate. This explanation accounts for the motor in the above case running only at about a little more than one-third its normal speed.

Fig. 3

Reducing Arcing of Buzzer Contacts

A simple and effective way to save buzzer contacts from being prematurely burnt out is to connect a telephone condenser of about 2 mfd. capacity across the contact points. In cases where these points were burnt out in certain service in about three months, the service of buzzers was extended to more than a year by shunting a condenser across the contacts. This is a great saving in the repair bill for it costs as much in labor and material to repair the points of a buzzer as a new buzzer would cost. A 2 mfd. capacity condenser may not be suitable for all buzzers, therefore, it is a good idea to try different capacities until the sparking stops.



Questions for March

1. *I am anxious to secure a little information that will help me in the design of a spot welding transformer. What voltage and current does it take to spot weld two pieces of jacket iron together, the iron being 1/16 in. thick? The transformer I want must operate on a 220-volts, 60-cycle power line. What size copper will I need on primary and secondary and how many turns on each? What size core will I need?* C. M. G.

2. *Can you illustrate the law showing the relation between the line loss and voltage on a transmission line?* E. C.

Spot Welder Design

1. To give full and complete information with working drawings, etc., of a spot welding machine would be outside the scope of this department, but a few points may be given here that will be helpful to any one who is interested in this problem.

For welding jobs such as you have in mind it is common practice to use a transformer of about 12 kw. capacity. A voltage on the secondary of from three to five volts would probably prove satisfactory. Presumably, if the turns on your primary correspond in size and number to the turns on the 220 volt winding of a 12 kw. transformer, you will have the right number. This number probably will vary considerably with the amount and quality of iron in the core. The number of turns in the secondary will be as 5 is to 220 in relation to the number of turns in the primary.

The operation of spot welding includes a number of variables. A given job can be done in a certain amount of time with a given current, and if the current is increased, the time can be reduced. The amount of pressure between sheets also affects the time and current used. In addition to this, if a large width of iron is included between the jaws of a welder it will have an inductive effect on the transformer, which will cut down the current in the secondary. In some cases, the amount of current is reduced considerably by having two sheets to be welded touch only at the spot where the welding is to take place.

Loss on Transmission Lines

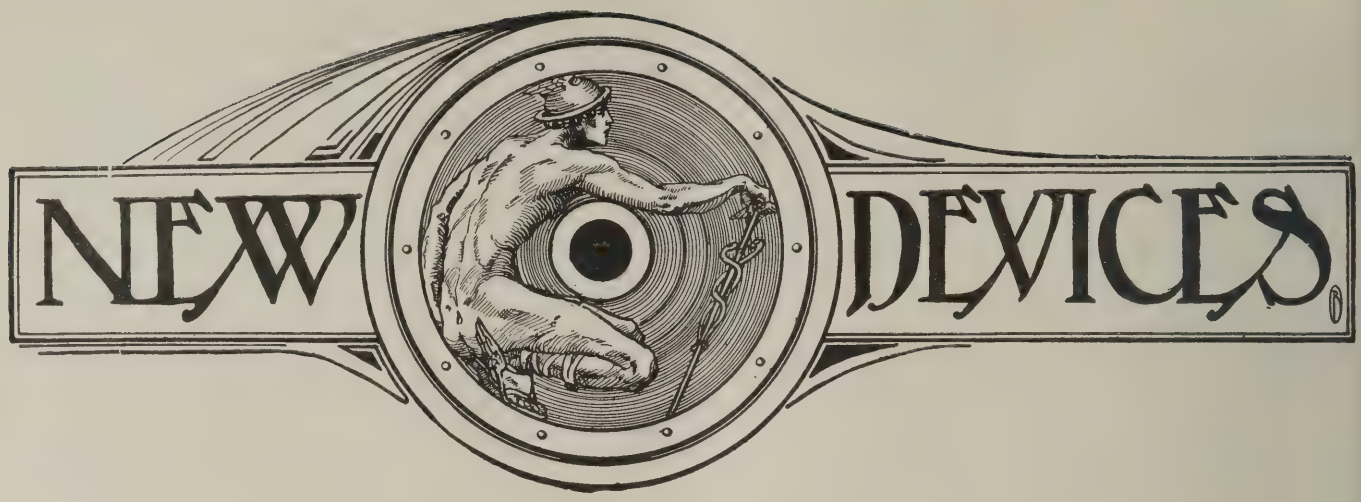
2. In planning a transmission line it is necessary to make an allowance for the energy consumed in the transmission of the power. When the watts to be lost in the line and the transmission voltage is decided upon it is relatively a simple matter to determine the size of conductors necessary. The higher the transmission voltage, the smaller will be the watts lost for the same size of conductors, but since the watts to be lost is previously determined, it follows that in order to maintain this fixed loss, as the transmission voltage is increased the size of the conductors will become smaller. In fact, *with the same loss on the transmission line, the cross section of the line conductors will be inversely proportional to the square of the voltage of transmission.* As an illustration, suppose 50,000 watts are to be transmitted and that 1,000 watts is the permissible loss on the line. If the energy is delivered at 50 volts and the weight of copper required is 1,000 lb. then the comparative weight of copper for other voltages according to the foregoing law is given in the following table:

Energy Transmitted			Loss on the Line			Copper Required
Kw.	Volts	Amperes	Volts drop	Amperes	Watts	Pounds
50	100	500	2	500	1,000	1,000
50	200	250	4	250	1,000	250
50	500	100	10	100	1,000	40
50	1,000	50	20	50	1,000	10

Questions for April

1. *Why is it that an electro-magnet of the horseshoe type, one end of which is rounded, has the greatest tractive power on the rounded end?*

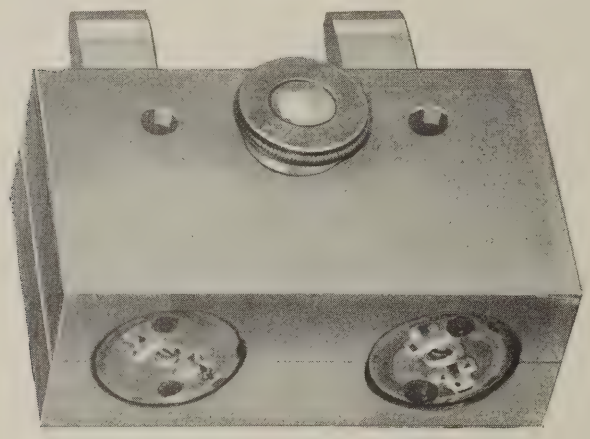
2. *I would like to use a voltmeter to measure insulation resistance of conductors. Is this practical?* J. W.



Marker and Sign Plug

A marker and sign plug, designed to provide outlets for either electric markers or signs on electric lighted trains, has been developed by the Central Electric Company. The plug consists of an insulating block in which are mounted two or three finger contacts made of aluminum which will fit any Gibbs standard train line connector, a fuse block of ample capacity, and two Hubbell T-Slot receptacles which will take any standard GE or Hubbell plug cap.

As the Gibbs receptacle on the rear end of a train is never in use, all that is necessary in order to connect elec-



Ralco Type V R Marker and Sign Plug

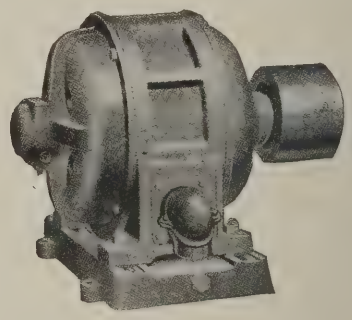
tric markers or electric signs on any train is to insert this plug and two outlets are immediately available.

The plug is a new member of the Ralco family and is made in two styles; the VR-2 plug for axle generator systems and the VR-3 plug for head end systems where the loop is closed on the rear car of the train.

Two New Motors

Two new lines of motors are now being offered by the Western Electric Company. One of these lines is the SCR single-phase motor and the other is the type KT riveted frame polyphase motor.

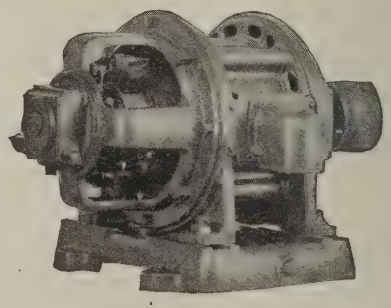
The SCR motor starts as a repulsion type motor and operates on the squirrel cage induction principle. Short circuiting switches are eliminated and the motor is simple in construction. The motor combines high starting torque with comparatively low starting current. Operating characteristics are similar to those of an induction motor. Both maximum and accelerating torque approximate 200 per cent of full load torque without any low points during acceleration. No load and full load speed are respectively about three per cent above and below



Type KT Polyphase Induction Motor

synchronous speed. The stator windings consist of concentric polar windings arranged for double voltage connections. The rotor contains a cast squirrel cage winding and a multiple type repulsion wire winding with equalized commutation connections to insure uniform distribution of armature currents.

The KT motor represents an entirely new type. It is



Type SCR Repulsion-Induction, Single Phase Motor

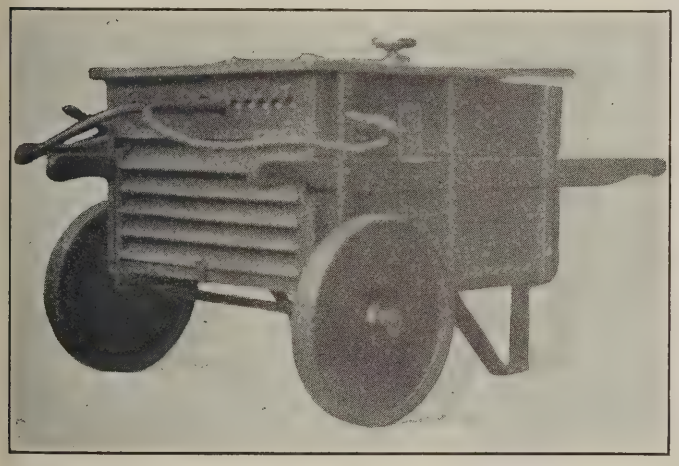
a 40-deg., continuous duty, riveted frame motor and is available up to sizes of 15 hp. The motor differs from polyphase induction motors made previously by this company in that there is less heating at a given load, higher efficiency, higher power factor at full load and fractional load and increased starting torque. The maximum torque for different sizes ranges from 275 per cent to 300 per

cent of full load synchronous torque and there are relatively few dips in the accelerating torque curves. Compared with previous types, the KT motor is built with from 50 to 100 per cent increase of oil reservoir capacity, a new method of directing ventilating air which assists cooling and prevents dirt settling on the windings and a cast one piece rotor which has neither joints nor high resistance spots.

One-Man Portable Universal Welder

A new type of welding transformer has been developed by the Electric Arc Cutting & Welding Company, Newark, N. J. It is called universal because it can be operated from almost any shop supply circuit whether it is alternating or direct current and the manufacturers offer it for doing all kinds of arc welding and also for nickel spotting, lead burning spot-tack welding and various other welding applications.

Previous designs of welding transformers made by this company could be used on alternating current voltages such as 220-440 or 110-220. This unit which is no larger than the regular size can be used on the 110, 220 or 440 volts alternating current by means of multiple, series multiple and series combinations of the coils of the primary winding. To make the same machine operate on 25 and 40 cycles, taps and adapter windings are used to obtain the proper electrical characteristics. Operation of the blower



Barrow-Type Universal Arc Welding Machine

and automatic switch are not interfered with by any of these circuit combinations. In addition to this, the apparatus can also be operated on 110 and 220 volts direct current by means of a resistor-reactor combination which is inserted in the circuit together with the secondary winding.

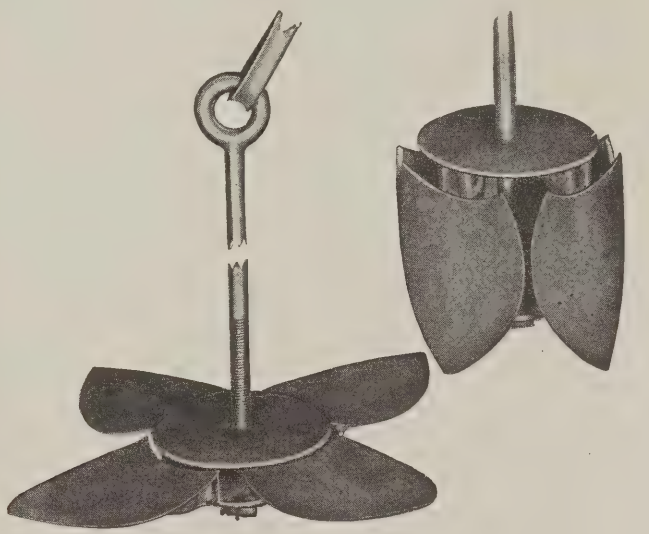
The core of the transformer is made of silicon steel. The windings are of double asbestos magnet wire each layer of winding separated from the next by pure mica. The primary is separated from the secondary by four layers of mica and ¼-in. asbestos spacers. The machine has all welded joints so that there is nothing in its construction which will melt or char.

Previous designs of these welders, which weigh about 200 pounds, were carried by two men. The machine has now been made easily portable by one man by the addition of wheels at one end and an extension of the side handles at the other so that it can be moved about like a wheelbarrow. The machine is furnished either with or without the wheeling arrangement.

Expanding Guy Anchor

The Signal Accessories Corporation of Utica, N. Y., has recently placed on the market an expanding guy wire anchor for use in connection with pole line construction. The anchor is furnished in two distinct styles, namely, of gray iron designated as Type-A, and malleable iron or Type-B anchors. Both types have an expanded spread of 18 in. and a normal or contracted circumference of approximately 7 in. Rods for the anchor are furnished either plain, painted or galvanized in lengths of 6, 7 or 8 ft.

To install a Saco expanding guy anchor, an 8 in. hole



Expanding Guy Anchor in the Closed and Open Positions

is dug or bored to the required depth and at the proper angle, the anchor inserted in the hole and expanded by turning the red with a reverse or counter-clockwise rotation, 30 to 35 revolutions. The upper and lower plates gradually approach each other, which action forces the four blades into undisturbed earth leaving no voids to fill and settle later. It is claimed that the Saco anchor is locked at any position of its expansion and cannot be collapsed without rotating the rod. Should it be desirable to reclaim or remove the anchor for installation at another point, it can be accomplished by merely loosening the dirt for a distance of 4 in. around the rod and then turning it 30 to 35 times in a clockwise direction, collapsing the blades and so loosening the anchor in the ground to allow for its removal.

Distant Dial for Watthour Meters

The General Electric Company has developed a distant dial mechanism for use with watthour meters where, for various reasons, it is desired to have the registration of the meter appear at a point remote from that where it is installed. This device is actuated through a contact mechanism in the register of the watthour meter.

General News Section

E. D. Allmendinger, manager of the foreign department of the Black & Decker Manufacturing Company, Towson, Md., sailed for England on March 15th.

The Interstate Commerce Commission has granted a petition of the New Orleans Great Northern for a modification of its train control order of January 14, 1924, exempting that road from compliance therewith.

The Western Railway Club will hold its annual meeting on Friday evening, May 23, at the Edgewater Beach hotel, Chicago. Fred W. Sargent, vice-president of the Chicago & North Western, will be the speaker of the evening.

One span of the bridge of the Western Maryland over Willis Creek, Cumberland, Md., was carried away by a flood on March 31, together with 20 carloads of sand which had been placed on the bridge in the hope of keeping it in place.

A freight train of the Baltimore & Ohio broke through a bridge near Newark, Ohio, on March 29, and the locomotive and eight freight cars fell into the stream. Four trainmen were killed. The failure of the bridge is said to have been due to a flood.

At Woodford, Va., on the Richmond, Fredericksburg & Potomac on April 2, the southbound Florida Special of the Atlantic Coast Line was derailed and the locomotive was overturned. The engineman was killed and the fireman was injured. Eight coaches left the rails.

The Dixie Limited southbound, of the Chicago & Eastern Illinois, was derailed at Cayuga, Ind., on March 29, the engine and first two cars being thrown off the track at the derailing switch approaching the crossing of the New York, Chicago & St. Louis. Three employees were slightly injured.

The Electric Controller & Mfg. Co. announces the combination of its Boston and New York offices. W. R. Yorkey, who has been in Boston, will now be district manager of the New York office. Also, a new branch office has been created in Philadelphia with H. K. Hardcastle as district manager.

The Canadian National has equipped its International Limited, which runs between Chicago and Montreal, Que., with radio apparatus for the reception of programs from Canadian and American broadcasting stations. A receiving set and loud speaker are installed in the observation car. The loud speaker can be detached and head sets can be used by the passengers if desired.

The Rome Wire Co., Rome, N. Y., which purchased the capital stock of the Atlantic Insulated Wire & Cable Company of Stamford, Conn., in 1922, has announced its intention to bring the machinery of the latter company to Rome, N. Y., during the coming summer from which point the business will be managed. The brands of wire manufactured by the Atlantic company, namely, "Dolphin," "Triton" and "Neptune" will be continued, and necessary additions to the Rome plant have been commenced.

H. H. Galleher, foreman of the high voltage laboratory of the Westinghouse Electric & Manufacturing Company, has been awarded the Insull medal for resuscitation, awarded by Samuel Insull, president of the Commonwealth Edison Company, through the National Electric Light Association to any employee of a member company who resuscitates a person from electric shock by the prone pressure method. Mr. Galleher recently displayed great presence of mind in rescuing and resuscitating R. P. Redman of the Westinghouse Company, who had come in contact with a line carrying 100,000 volts. The presentation was made by R. S. Feicht, director of engineering of the Westinghouse Company, in the presence of employees and officials of the company, assembled at its East Pittsburgh works.

No More Exhibit Space for Atlantic City Convention

The exhibit committee of the Railway Supply Manufacturers' Association early in March completed the assignment of all available exhibit space, 100,234 sq. ft., for the convention of Division V, Mechanical, American Railway Association, to be held in Atlantic City in June. Applications were received for 115,000 sq. ft. of space.

Baltimore & Ohio Electrification on Staten Island

The electrification of the Baltimore & Ohio Railroad on Staten Island has been begun and the first work in this connection will be the elimination of grade crossings. It is estimated that about $15,000,000 will be spent although if all of the freight lines on the island are electrified the cost will greatly exceed that amount.

The system to be used is 600 volt direct current and the cars are to be of a type that is interchangeable with those of the Brooklyn-Manhattan Transit Company.

Messages by Radio on the D. T. & I.

The Detroit, Toledo & Ironton has three radio stations —Dearborn, Mich. (KDEN), Springfield, Ohio (WNA), and Jackson, Ohio (WJQ); and the station at Dearborn sends 400 messages a day to Springfield and Jackson. Springfield is 200 miles distant and Jackson is 300 miles. Preparations are being made to increase the capacity of the station to 2,000 messages a day (8 hours). Between Dearborn and the factories of the Ford Motor Company at River Rouge, a printing telegraph system is employed.

The station at Dearborn has three towers, each 165 ft. high, and the antennæ are 360 ft. long and consist of five

wires each. The wave lengths are 1,713 at Dearborn, 1,875 at Springfield and 1,934 at Jackson.

The Western Electric Company

The annual report of the Western Electric Company for the year ended December 31, 1923, shows a net income of $10,079,471, equal to $20.15 per share on the 500,000 shares of no par common stock outstanding. Sales during the year established a record with a total of $255,177,122, compared with $210,041,004 in 1922. Unfilled orders of the company on December 31, 1923, aggregated $94,951,000, or an increase of $32,882,000 over the total at the end of 1922.

The income account for 1923 and the balance sheet as of December 31, 1923, are as follows:

INCOME ACCOUNT

	1923	1922
Sales	$255,177,122	$210,941,004
Other income	1,302,874	2,690,836
	$256,479,996	$213,631,840
Cost of merchandise	$225,751,351	$189,418,973
Expenses	18,239,356	12,716,973
Taxes	2,409,818	1,860,004
Special appropriations	.....	400,000
	$246,400,525	$204,395,950
Available for interest and dividends	$10,079,471	$5,331,793
Interest deductions	$1,159,958	$3,904,097
Dividends—		
On preferred stock 7 per cent per annum	1,727,572	.....
On common stock, $10 per share, 500,000 shares	5,000,000	.....
	$7,887,530	$4,186,857
Balance carried to common stock	2,191,941	1,144,936

BALANCE SHEET

Assets

	1923	1922
Land, buildings and permanent fixtures	$23,449,884	$20,257,973
Machinery, tools and other equipment	33,915,918	28,947,552
	$57,365,802	$49,205,525
Investment in and advances to International Western Electric Company, Incorporated	14,476,865	15,135,561
Other investments	2,238,820	2,309,432
Merchandise, materials and supplies	69,349,002	52,701,893
Trade acceptances and bills receivable	1,066,727	1,200,838
Accounts receivable	44,311,960	36,624,943
Prepaid charges	462,556	.....
Marketable securities	108,000	.....
Liberty Bonds	.....	7,000
Cash	12,053,342	11,008,869
Total working assets	$127,351,587	$66,650,518
Grand total	$201,433,074	$168,194,061

Liabilities

Common stock, no par value, 500,000 shares authorized and issued	$77,128,767	$74,931,826
Preferred stock, 7 per cent cumulative, par value $100	24,679,600	24,679,600
Total capital stock	$101,803,367	$99,611,426
Bills payable	$35,000,000	$12,000,000
Trade acceptances and bills receivable discounted	$705,659	$618,563
Interest and taxes accrued not due	2,655,755	.....
Accounts payable	20,056,533	18,614,694
Total current liabilities	$58,417,947	$31,233,257
Reserve for depreciation on plant and equipment	34,404,141	30,431,368
For Employees' Benefit Fund	2,000,000	2,000,000
For Contingencies	4,807,619	4,918,010
Total reserves	$41,211,760	$37,349,378
Grand total	$201,433,074	$168,194,061

Otheograph Used in Locomotive Tests

Operating officials from a number of important steam railroad systems are co-operating with the General Electric Company in conducting operating tests with locomotives to determine the limits of adhesion during acceleration and running with various train weights and different conditions of rail.

The otheograph, demonstrated last December at the Erie works of the General Electric Company, will play an important part in the tests.

The equipment used will be a Mikado type freight locomotive No. 74, furnished by the New York Central Railroad; one of the new Mexican locomotives, recently completed at the Erie works of General Electric, and a G-E experimental locomotive No. 18.

The trailing train used with the above locomotives in turn will be made up of a dynamometer car, 10 loaded coal cars and a coach giving a total weight of approximately 1,000 tons.

Another train will consist of the dynamometer car, five coal cars and a coach, approximately 600 tons.

The tests will be repeated on a dry rail, a dry rail sanded, wet rail, and wet rail sanded.

General Electric Employees Subscribe to Bonds Issue

Employees of the General Electric Company are owners of, or are paying on the installment plan for, a total of $11,458,260 in G-E Employee's Securities Corporation bonds. This was announced after a tabulation had been made of the subscriptions to the third offering of these bonds, these subscriptions amounting to $5,339,800.

The total bonds subscribed for in all three offerings, in the various factories of the company, are as follows: Schenectady, $3,584,010; West Lynn, $373,570; River Works, Lynn, $1,196,400; Pittsfield, $737,570; Erie, $833,770; Fort Wayne, $742,150; Edison Lamp Works, $617,140; National Lamp Works, $1,003,310; all other factories, $581,790; general office, $986,120; district offices, $802,430.

The number of the company's employees who have subscribed to these bonds, which pay 8 per cent as long as the individual remains with the General Electric, is around 267,100.

Electric Storage Battery Company

For the year ended December 31, 1923, The Electric Storage Battery Company reports gross sales of $11,836,030 against $11,966,681 in 1922 and net income before federal taxes of $7,216,522 as compared with $7,570,839 in 1922. Dividends were paid totaling $4,010,145 in 1923 and $3,196,685 in 1922.

The consolidated balance sheet of The Electric Storage Battery Company and the Willard Storage Battery Company, as of December 31, 1923, compares as follows:

ASSETS

	1923	1922
Cash	$3,218,121	$2,485,474
Bills and accounts receivable	5,541,555	5,354,555
Obligations of the United States	3,867,524	4,743,034
Industrial, railway and utility bonds	1,075,936	831,795
Accrued interest receivable	67,651	70,098
Inventories	9,345,946	7,928,280
Other investments	1,665,002	1,642,053
Deferred accounts	581,213	404,956
Real estate, plant and equipment	11,419,161	10,624,585
Patents, trade-marks and agreements	5,000,001	11,000,001
Insurance fund, cash and securities	144,435	116,194
	$41,926,544	$45,201,024

LIABILITIES

Accounts payable	$2,818,352	$2,321,025
Accrued accounts	366,953	341,572
Employees' stock subscriptions, collections	42,831	.....
Reserves	615,422	601,337
Preferred stock	32,400	32,400
Common stock	19,946,925	19,946,925
Surplus*	18,103,661	21,957,765
	$41,926,544	$45,201,024

*Subject to allowance for federal income tax for year 1923, estimated at $850,000.

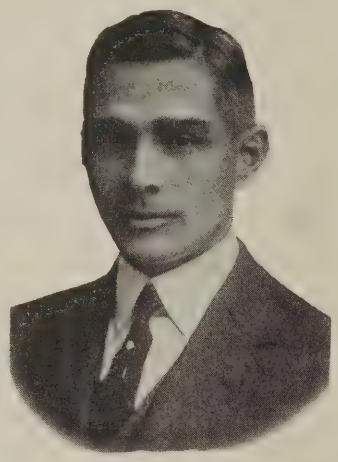
Japanese Railways Extend Time Limit on Improvement Program

The Japanese Department of Railways has, in view of the heavy expenses necessitated by the September quake, altered its ten-year construction and repair program recently adopted. The total amount of capital to be spent for the realization of the plan has not been changed, but the time limit on the program has been placed at eleven or twelve years.

The whole construction budget is given at 612,995,000 yen. Of the total 27,404,000 yen is to be set aside for the purchase of locomotives and cars. The credit for repairs and improvement is placed at 676,960,000 yen. Of the figure 150,127,000 yen is to be spent in purchasing locomotives and cars. The purchase of locomotives and cars is to be completed by 1928. The electrification of some trunk lines figures prominently in the altered program. The Department of Railways proposes to spend 81,000,000 yen for the installation of electric plants. Roughly 300,000,000 yen is to be used in replacing old rails.

Personals

Charles N. Winter, managing editor of the Locomotive Cyclopedia and the Car Builders' Cyclopedia, has resigned to become general manager of the Rogatchoff Company of Baltimore, Md. Mr. Winter began his engineering career in 1904 in Poughkeepsie, N.Y. In 1906 he entered the engineering department of the American Brake Shoe & Foundry Company, serving as draftsman and as engineering inspector of new work. He resigned this position to enter the engineering department of the American Car & Foundry Company at New York; in 1913 returning to the American Brake Shoe & Foundry Company as chief draftsman. In 1915 he moved to Virginia, where he served in the test department of the Norfolk & Western Railroad at Roanoke, and in the office of the engineer at the Richmond works of the American Locomotive Company.



C. N. Winter

In 1918, Mr. Winter accepted a position on the editorial staff of the Simmons-Boardman Publishing Company and compiled the 1919 edition of the Car Builders' Cyclopedia. At the close of this work he became associate editor of the Railway Age and the Railway Mechanical Engineer. In 1921 he became managing editor of both the Locomotive Cyclopedia and the Car Builders' Cyclopedia, resigning from this latter position to take up his new duties which will include the direction of sales and advertising for the Rogatchoff Company in the United States and Canada, and also in Great Britain and Australia. The sales offices will be located at 90 West Broadway, New York City, and in the Koehler Building, Ridgewood, N. J.

H. K. LeSure, chief electrician in the office of the general superintendent of motive power of the Eastern Region of the Pennsylvania, has been appointed master mechanic of the New York Terminal.

Patrick F. Lyons, Middle Western district manager of the wire division of the United States Rubber Company, has resigned, effective April 1, 1924. Mr. Lyons became identified with the National India Rubber Company, which was a subsidiary of the United States Rubber Company, at that time with headquarters at Bristol, R. I., in 1899, representing it in the south and middle west and became district manager when it opened up its Chicago office in 1911.

Obituary

Sidney L. E. Rose, for 15 years an engineer in the illuminating engineering laboratory of the General Electric Company at Schenectady, died March 17th in St. Louis. He was born in Tamworth, Ontario, Canada, in 1877. He was graduated from Queens University in Ontario in 1903 and in 1905 joined the General Electric test at Lynn. Two years later he was transferred to the illuminating engineering department and, when this department was moved to Schenectady in 1909, he came with it. For several years he was in charge of the photometric work and was widely known.

Trade Publications

Roller-Smith Company, New York, in its bulletin No. 400, illustrates and describes direct current switchboard instruments. The list includes ammeters, milli-ammeters, voltmeters, milli-voltmeters and volt-ammeters.

The General Electric Company has recently issued three small pamphlets which constitute the indexes to its various publications. One of the pamphlets is the index to supply part bulletins; the second, to descriptive publications, and the third to instruction books and cards.

The Independent Pneumatic Tool Company, Chicago, Ill., has recently issued a four-page, illustrated folder describing the Thor universal electric tapping machine. The machine is designed for tapping small holes and for retapping larger sized holes up to 5/16 in. A universal motor using a. c. or d. c., 110-220-volts is used. The speed of the spindle is 550 r. p. m.

Postal Car Lighting.—The Safety Car Heating & Lighting Company, New Haven, Conn., has issued a 1924 edition of its catalogue on Postal Car Lighting. The catalogue describes conduit, wiring and fixture installations which conform to post-office department specifications and it is distinctive in publications of its kind in that it is, in reality, a text-book on the subject of postal car lighting. It contains 77 pages and is profusely illustrated. It contains post-office department specifications on lighting, descriptions of electric and gas lighting equipment and layouts for 70-ft. and 60-ft. mail cars, and for 30-ft. and 15-ft. mail apartments.

Railway Electrical Engineer

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The June Convention

From every point of view, there is much to indicate that the semi-annual meeting of the Association of Railway Electrical Engineers this year will exceed all of its previous meetings or gatherings. It will be recalled that there was no June meeting held last year and this in itself is sufficient to stimulate considerable interest in next month's meeting.

The day set for the meeting this year is June 12 which falls on Thursday. It will be noted that this is a change from previous years as the meeting has usually been held on Monday morning. Whether or not this will have any effect on the attendance is a question, but the chances are that the attendance will not suffer much, if any. Moreover, there is a most excellent reason for having the day of the meeting changed. It will be remembered that at some of the previous Atlantic City meetings certain reports were presented both to the Association of Railway Electrical Engineers and to the Mechanical Section of the American Railway Association which was also in session at the same time. Unfortunately, it so happened that the same hour was set for presenting the same report by the same committee, at two different places—an impossible situation. In order to avoid this conflict again, the day for the meeting was changed to June 12.

It is impossible to predict just what progress has been made by the various committees but if the number of committees has any significance, there will be plenty of material for a lively discussion. In view of the fact that the convention is in session but one day and that there are 14 committee reports to be presented, it is plainly evident that the electrical men are scheduled for a busy day.

The Railway Electrical Engineer for June will contain all of the reports of the several committees.

The June issue will be mailed as early as possible in order that those who live furthest away from Atlantic City may have an opportunity to read the reports before leaving for the convention.

The Railway Supply Manufacturers' Association, which will have an exhibit at this time, expects a record-breaking attendance. All of the space for exhibit purpose on Young's Million Dollar Pier (and the space has been considerably enlarged this year) has been taken; an additional building is being erected for exhibits at the street end across the Boardwalk from the pier. There will undoubtedly be numerous new appliances which will be of greatest interest to electrical men.

In short, the outlook for the June Convention season this year in Atlantic City seems to be brimful of interesting and instructive activities which railway electrical engineers cannot afford to miss. Make your plans now to be on hand on June 12 at least and longer if possible. The interchange of ideas with the other fellows from all parts of the country will be vastly more profitable to you and your company than the same time would be if spent in any other way.

Steam and Electric Locomotives

"The modern steam locomotive is the result of 100 years development and it is a most marvelous machine to which mankind owes much. Its performance and limitations are both faithfully reflected in railroad transportation today. Train weights, operation, schedules, capital expenditures, revenues, all are dependent upon what the steam locomotive can do. The railroad operator and financier think in terms of steam locomotive performance and the whole railroad structure, physical and administrative, is founded upon the well understood operation and restrictions of the steam locomotive." The preceding graphic description of a situation is quoted from a paper presented to the St. Louis Railway Club and the American Institute of Electrical Engineers at St. Louis, Mo., on March 14 by A. H. Armstrong, chairman electrification committee, General Electrical Company.

About one per cent of the mileage of railroads in the United States has been electrified since 1895 and although railroad conditions are improving, there does not seem to be any rapid increase in the rate at which electric traction is being adopted. In spite of this fact, there is an apparently unwarranted apprehension concerning the adoption of electric traction shown by builders of steam locomotive equipment. This is probably because electrification appears to strike at the foundation of railroad structure.

Unbiased and sober consideration of the situation will show that there is no reason for alarm on the part of the steam men and there is good reason for optimism on the part of the electrical men. In nearly all cases where electric traction has been installed on roads in the United States it has been done to meet some special condition that could not be met with steam power. With the building of tunnels and improving of large passenger terminals more of these conditions will arise during the coming years but the rate will not be rapid.

It is in the field of large freight power that the electric locomotive becomes a real competitor. The electric locomotive is peculiarly suited for hauling heavy freight trains at relatively high speeds. On the other hand there is a tendency on the part of the railroads to use fewer Mallets and more Mikado and Pacific type steam locomotives. Whether or not there is any significance in this trend is a

matter for speculation. It would appear, however, that the steam locomotive builders intended to improve their position in a field which is rightfully theirs and that the possibilities of using more electric locomotives in the heavy traction field are increasing.

Carbon Arc Welding

At the recent annual convention of the American Welding Society held in New York, there was presented at one of the sessions some very interesting information concerning the use of carbon arc welding. One of the members of the society, who has given much study to this particular branch of welding, pointed out in a brief, extemporaneous talk some of the advantages of carbon arc welding over metallic arc welding as he had found them in daily practice in railroad shop work. On different occasions in the past, the amount of time required to train a welding operator has been variously stated at from two weeks upward. The speaker in this instance mentioned what would be looked upon by many as an abnormally long period of training, for in his opinion, three or four years are required in order to bring a welding operator to the point where he can be depended upon to perform any kind of work that may come his way.

If this time is required to produce a high grade carbon arc welder, the effort is not altogether without its compensations for when properly used in the hands of an experienced operator, it is found that work can be performed at a rate which is two and one-half or three times as fast as is possible with the metallic arc process. Moreover, the carbon arc welder while he is learning the various phases of this type of welding is by no means a total loss as there are, of course, numerous opportunities to practice with the carbon arc where serious consequences would not follow the failure of the weld. In addition to this, there appears to be a better disposition of metal in the welded joint with the carbon arc process than with the metallic arc. Carbon arc welding has not universally received the same attention that metallic arc welding has but if similar results to those indicated can be readily obtained in other shops, it is evident that this important process should be more extensively used and that a closer study of the carbon arc would pay generous dividends in future economies affected.

Should Railroads Purchase Power?

With the ever increasing use of electric energy in the different railroad departments, the question of whether or not it is advisable to purchase or generate power becomes more and more important. Of course, in the ultimate analysis, the matter resolves itself into the fundamental question of economy. If it is possible to purchase power from some reliable power company at more favorable rates than it can be generated by the railroad itself, it would seem that the power should be bought and not generated by the railroad company.

It is true that purchased power supply has been known to fail, but it is much more certain not to fail than that of the usual steam railroad power plant. Where large quantities of electric power are used, it might be thought that the railroad company could compete favorably with the power companies in its generation, but even in this instance it is more than likely that the power company can generate power at a lower rate. The reason for this is the better over-all efficiency of its power plant. The generation and sale of power is the power company's business and the more power it can sell, within limits, the cheaper will be the cost per kilowatt hour. Because of the many diversified uses for power, the load factor is better than that of the railroad power plant and all other things being equal, the better the load factor, the cheaper will be the cost of power. Furthermore, with regard to the liability of power failure, the chances of this are much more remote for the power company because of its interconnected systems by means of which a number of plants may be tied together so that should trouble develop in one, the other stations can carry the load.

The problem is one which calls for individual study, but with all the means for economical operation which the power company can afford to install and which the railroad company usually cannot afford, the generation of cheap electric power would seem to lie with the former and not with the latter. Perhaps it is just as well that this is the case for if a dependable source of cheap power is obtainable, there is no real excuse for the railroad to enter this field at all. The railroad has many problems of its own which strictly pertain to railroad operation and it can well afford to let someone else furnish the electric power to meet its requirements.

New Books

EMF Electrical Year Book—1,550 *pages, illustrations, diagrams. Published by Electrical Trade Publishing Co., Chicago. Price* $5.00.

The third annual edition of the "EMF Electrical Year Book" has just been issued. The book has been completely revised and materially added to. This book is a useful general reference work for the entire electrical industry, particularly in giving complete lists of manufacturers of almost every conceivable electrical product under nearly 3,200 classifications of equipment. There are also definitions of over 5,900 electrical words and terms, and nearly 600 encyclopedic topics on the different branches of the industry, the leading electrical activities, inventors and scientists, associations, educational institutions, periodicals, etc. Several hundred illustrations have been added to the text, which is arranged alphabetically throughout for ease of reference.

"Super Power as an Aid to Progress"—By Guy E. Tripp, Chairman of the Board of Directors, Westinghouse Electric and Manufacturing Co., 60 pages, illustrated, 5 in. by 7½ in., bound in cloth. Published by G. P. Putnam's Sons, New York.

The book is a collection of articles which have previously been published in various periodicals and newspapers. The subjects included are as follows: The Electrification of North America; Private Ownership vs. Government Ownership of Super-Power Systems; What America's Water Power Will Do for American People; Water Power and Statesmanship; States Must Not Isolate Their Water Power; Super-Power as an Aid to National Defense.

There is nothing of a strictly technical nature to be found in the book. It is rather, a summary of the advantages which would be enjoyed by the people with the advent of the cheaper power that is considered axiomatic with the development of the Super-Power System. With regard to the water power development alone it is pointed out that many millions of horsepower are continually going to waste in the United States and in the specific instance of Niagara Falls it is estimated that 3,000,000 horsepower could be developed.

Electrical Equipment at New Engine Terminal

Richmond, Fredericksburg & Potomac Railroad Solves Some Interesting Problems and Greatly Increases Facilities

THE new engine terminal of the Richmond, Fredericksburg & Potomac at Richmond, Va., which was recently put into service, brought much needed relief for the difficulties which had been experienced in handling the large number of locomotives in a small roundhouse. It is significant to state that previous to the completion of the new terminal, it was sometimes necessary to handle as many as 100 locomotives in 24 hours in a 12-stall roundhouse, a condition which taxes the ingenuity of all concerned to the utmost. In the new engine terminal, there is ample capacity not only for present, but for the future growth for many years to come. The recently completed structure has 30 stalls and this number can readily be increased to 42 should the occasion arise. In connection with the roundhouse there is also a large machine shop. The buildings are not only of ample capacity for the present needs and future extension, but have been most carefully planned in all of their appointments. On every hand there is abundant evidence that thought and consideration has been given to the numerous details that go into the construction of such buildings and particularly is this true in various applications of electrical energy to the requirements of the terminal.

The Incoming Engine Facilities—the Inspection Pit in the Foreground, with the Locomotive Tool and Inspector's House at the Right

Power Supply

The road does not generate its own power, having found it to be cheaper to purchase power from the Virginia Railway & Power Company, at a rate of approximately 1.1 cents per kilowatt hour. This cost is based on a monthly consumption of about 140,000 k.v.a. The power supply is brought to the railway company's property at Boulton shops at 2,300 volts and carried to a distance of about 2¼ miles to a transformer bank located immediately behind the roundhouse. This transformer bank is mounted on a platform supported by three wood poles. Upon this platform are placed six transformers, three for power purposes and three for lighting. All power used at the terminal is at 220 volts, 3-phase, 60-cycle, while all of the lighting is supplied at the same frequency at 110 volts. Between the 2,300-volt line which consists of three conductors on the topmost arm of the pole and the primary of the transformers are installed the usual cutouts mounted in individual boxes on a horizontal timber just above the transformers. Beneath the platform and also supported from horizontal timbers is a wooden cabinet which contains the meters used for measuring the power consumption. The lines are brought into the roundhouse through 4-in. iron conduit which is led under ground from the meter box. Inside of the building this conduit terminates in a large cabinet containing a slate panel upon which are mounted all of the fuses for the circuits throughout the shop for power as well as for lighting.

All heavy locomotive repairs are made at Boulton shops, only running repairs being made at the Acca locomotive terminal. The ultimate plans for the development at Acca call for the construction of a modern locomotive repair shop, including machine and erecting shops, smithshop, power plant, etc. When this project is completed the Boulton shop will be dismantled.

Transmission Lines and Connections

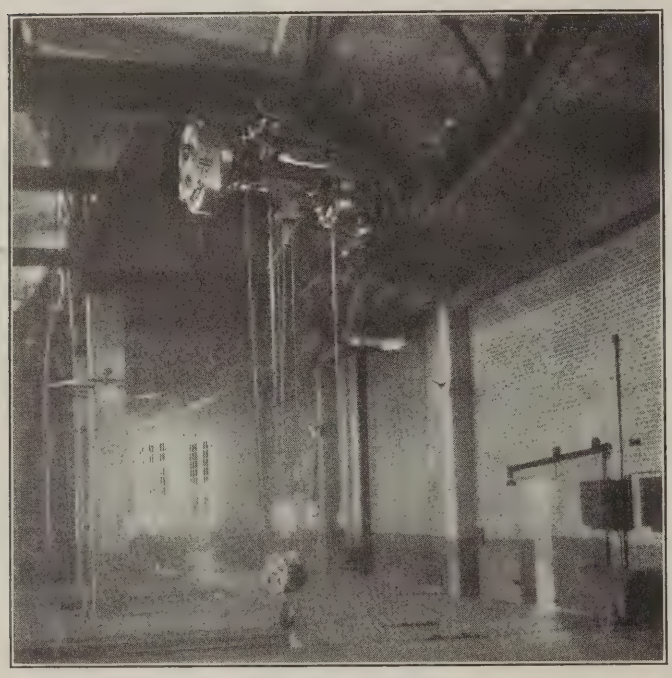
Since the Acca terminal is a later development, it was natural that the existing power lines should be extended from Boulton to Acca. The power is taken from the Virginia Railway & Power Company's mains at the Boulton plant at 2,300 volts, 3-phase, 60 cycles. The connections at this point are such that in the event of failure of the power company's supply, two generators located in the Boulton power house can quickly be pressed into service. While these generators are not sufficient to carry the entire load of the Boulton and Acca plants, they do serve to

prevent a complete shutdown in case of failure in the power company's supply.

There is at the present time an outdoor substation being constructed by the Virginia Railway & Power Company which is located at Acca and it is the intention to tap the power company's supply at this point also, stepping down the voltage from 13,000 to 2,300, at which voltage it will be transmitted to Acca and Boulton. Branch lines from the railroad company's 2,300-volt mains run into the Broad Street station, also supply the coach yards as well as other places and facilities adjacent to or between the two engine terminals. An inspection of the wiring diagram will give a very clear idea of the arrangement of the power lines.

Distribution System

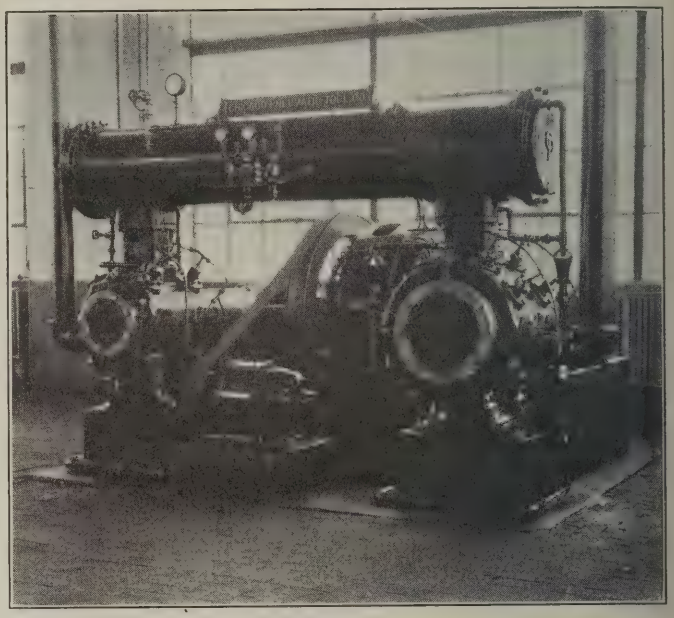
On entering the main panel box within the roundhouse after leaving the meter box on the pole, the wiring divides. Six conductors enter this main panel box, three of them being 110-volt circuits for lighting and three being 220-volt circuits for power purposes. All branch circuits are fused, some of the lighting circuits being run direct to their respective outlets, while the power circuits are led into large size conduits and run to the various motors. These 220-volt conduit lines are for the most part exposed being run along on the inside of the building to their respective motors. Many of the lighting circuits, however, are run directly from this panel box and buried in the concrete, not being exposed until they reach the lighting outlets.



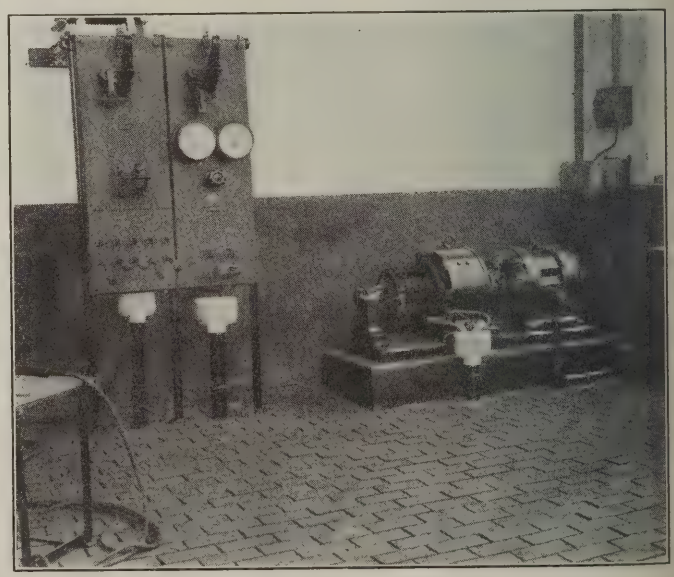
One of the Six-Ton Pawling & Harnischfeger Electric Traveling Hoists

The lighting for the roundhouse stalls is carried on in a different manner and one which is unique. It is a well-known fact that the gases which accumulate in roundhouses are particularly destructive to conduit and many methods have been tried to keep the conduit system away from the gases as much as possible. The method used at the Acca terminal is as follows: On leaving the fuse panel cabinet, three of the lighting mains are run directly outside of the building again and are carried around the outer wall near the top on a Pierce insulator rack. On this same rack, two other wires are also carried. These two wires carry current to the outer circle wall lights and these lights are controlled by a switch located at the end stall.

As may be seen from the diagram, at each typical stall the five conductors running around the outside of the building are tapped and led downward in ¾-in. conduit to a point 4 ft. above the floor of the building where they again pass through the wall into the cast iron cutout box in which is installed two Edison plug cutouts. From this box the outer wall circle light conduit leads upward and terminates in the lamp fixture. This piece of conduit is exposed, but all of the remaining conduit in the stalls is buried in concrete and terminates in junction boxes set in concrete and sealed with Chatterton's compound. In this way an effort has been made to prevent the locomotive

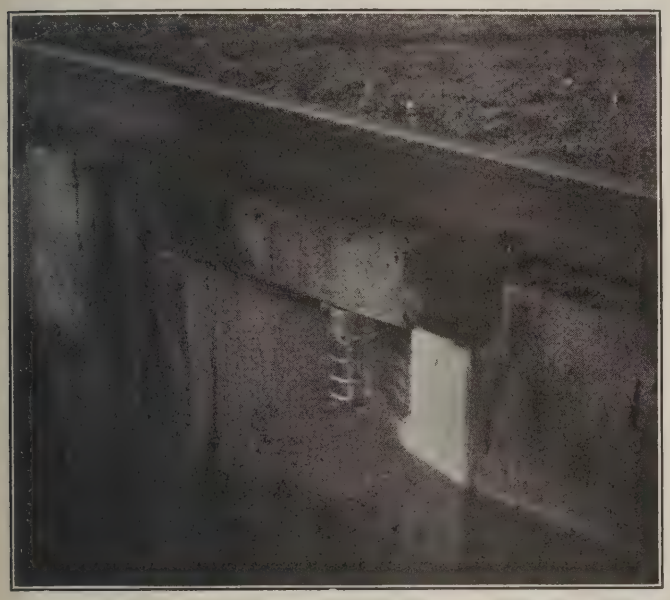


A Synchronous Motor Air Compressor Set Maintains Excellent Power Factor



Corner of Welding Room Showing Motor Generator Set and Switchboard

gases from gaining access to the interior of the conduit and destroying it. From the cutout box on the outer wall, two circuits are run to the columns in the stall. One of these circuits supplies current to two Ralco, two-gang receptacles from which extension cords may be used if desired. In connection with the lighting, it is interesting to note that the design of the roof is such that the gases will tend to dissipate very rapidly. The sloping character of the roof is responsible for this and is a very important factor in favor of long life to the conduit which is ex-



One of the Inspection Pit Lamps Mounted in Recess in Wall

posed. Many recently constructed engine terminals have used floodlighting lamps located upon the inner and outer walls of the building in order to secure good illumination, but those responsible for the lighting at the Acca terminal believe that better results can be secured by using mazda type C 100-watt lamps in Maxolite dome type reflectors.

Welding Facilities

In one corner of the shop a room has been partitioned off for doing welding work on such small parts as may be conveniently carried to this point. The equipment installed in this room consists of a Westinghouse two-operator motor-generator set operating at a speed of 1,750 r.p.m. The motor is connected to a 220-volt, 60-cycle, 3-phase circuit and at full load draws 66 amperes from the line. It is capable of carrying 100 per cent overload for an hour. The generator which is driven by this motor is known as type SK and has a rating of 18 kw. At the rated speed of 1,750 r.p.m. it furnishes 300 amperes of welding current at 60 volts and like the motor is capable of standing 100 per cent overload for a period of one hour.

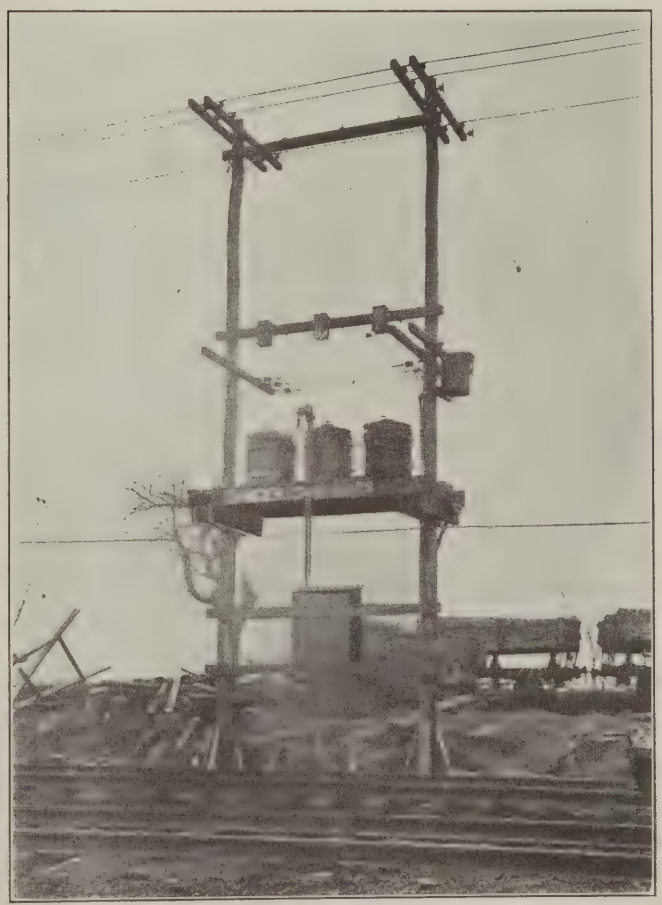
The motor is controlled by the Westinghouse auto starter type A which is used in connection with a safety electric switch mounted above it.

The welding switchboard consists of two panels. At the top of each panel is located a large circuit breaker. These breakers are for the purpose of protecting the welding cable which extends out into the machine shop and have nothing to do with the work that is done in the welding room.

The panel on the left carries two meters, one being a volt meter and the other an ammeter. Immediately below these meters is a small handle for the rheostat control. A large two-pole knife switch at the bottom connects the generator to the switchboard. At the lower portion of the left hand panel, five single throw, single pole knife switches are located which are used to cut in the various taps in the resistance which is mounted above this panel. All wiring around these panels is done with slow burning asbestos covered wire. As has been indicated, the operator may weld in the room or almost anywhere in the machine shop, as welding outlets are located at various columns throughout the shop. Electrical welding in the roundhouse is accomplished by means of a Lincoln portable electric welder, 220-volt, 3-phase current being supplied at alternate engine pits.

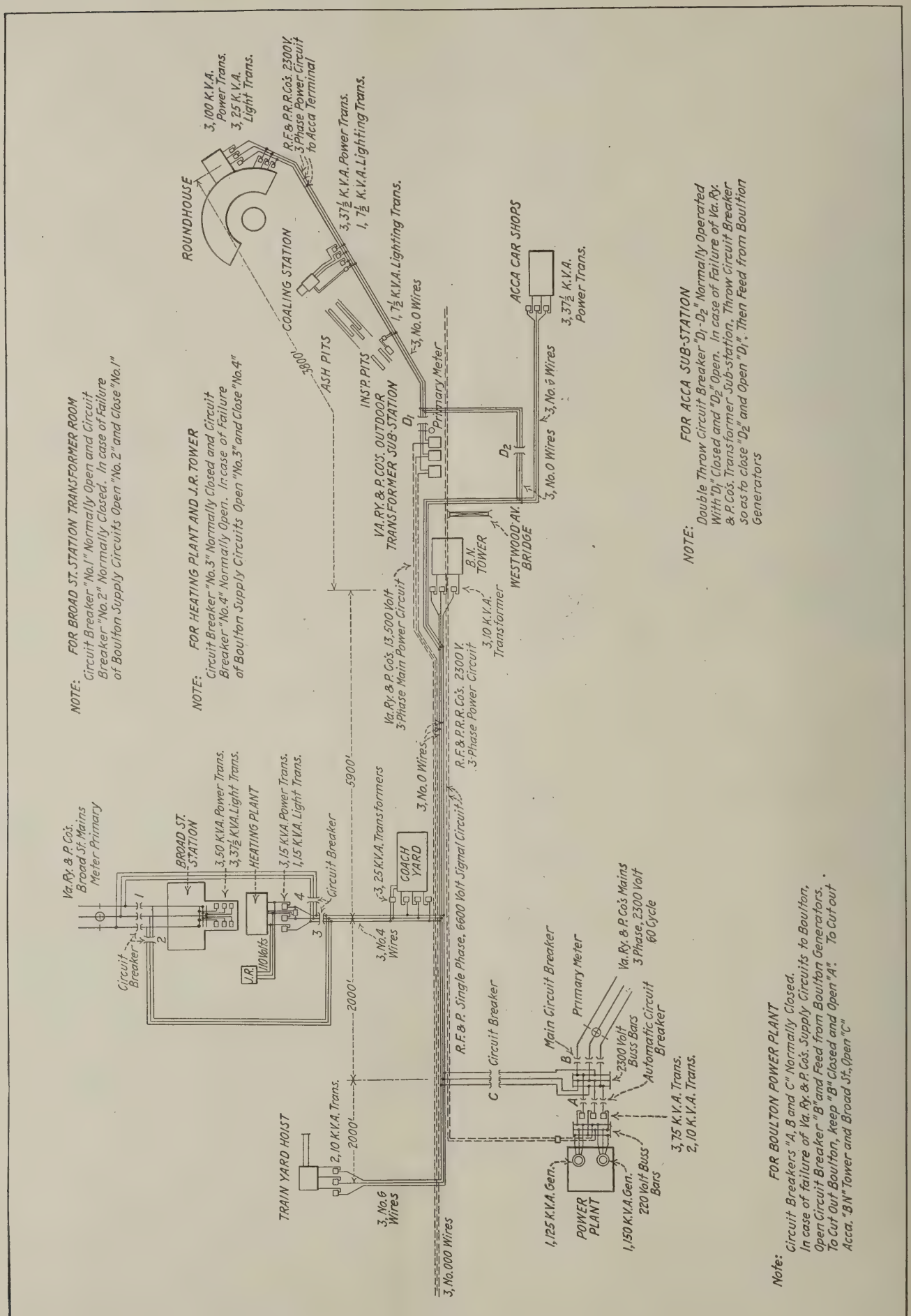
Power Factor Excellent

In keeping with what has become more or less standard practice in modern shops, a synchronous motor driving an air compressor is an important adjunct in the maintaining of a good power factor. The air compressor used in this instance is one designed by the Chicago Pneumatic Tool Company. It has a capacity of 613 cubic feet per minute.



Pole Construction and Transformer Bank Where 2300 Volt Line Is Tapped to Supply Coaling Station

The compressor is directly connected to a Westinghouse synchronous 220-volt, 3-phase motor which operates at 300 r.p.m. A small 5 kw. exciting generator which is compound wound is belted to the large flywheel of the synchronous motor set to furnish current to the fields of the latter machine. This smaller d.c. generator runs at a speed of 1,400 r.p.m. and has a capacity of 40 amperes at 125 volts with a reserve capacity of 100 per cent overload for 24 hours.


NOTE: FOR BROAD ST. STATION TRANSFORMER ROOM
Circuit Breaker "No.1" Normally Open and Circuit Breaker "No.2" Normally Closed. In case of Failure of Boulton Supply Circuits Open "No.2" and close "No.1"
NOTE: FOR HEATING PLANT AND J.R. TOWER
Circuit Breaker "No.3" Normally Closed and Circuit Breaker "No.4" Normally Open. In case of Failure of Boulton Supply Circuits Open "No.3" and Close "No.4"
Va. Ry. & P. Cos. Broad St. Mains Meter Primary
Circuit Breaker
BROAD ST. STATION
3, 50 K.V.A. Power Trans.
3, 3½ K.V.A. Light Trans.
HEATING PLANT
3, 15 K.V.A. Power Trans.
1, 15 K.V.A. Light Trans.
J.R.
110 Volts
Circuit Breaker
5900'
2000'
3, No.4 Wires
3, 25 K.V.A. Transformers
COACH YARD
3, No.0 Wires
Va. Ry. & P. Cos. 13,500 Volt 3-Phase Main Power Circuit
R.F. & P.R.R. Cos. 2300 V. 3-Phase Power Circuit
3, 10 K.V.A. Transformer
B.N. TOWER
WESTWOOD AV. BRIDGE
VA. RY. & P. COS. OUTDOOR TRANSFORMER SUB-STATION
D1
D2
Primary Meter
3, No.0 Wires
3, No.6 Wires
ACCA CAR SHOPS
3, 37½ K.V.A. Power Trans.
ROUNDHOUSE
3, 100 K.V.A. Power Trans.
3, 25 K.V.A. Light Trans.
R.F.&P.R.Cos. 2300 V. 3 Phase Power Circuit to Acca Terminal
3, 37½ K.V.A. Power Trans.
1, 7½ K.V.A. Lighting Trans.
COALING STATION
3900'
ASH PITS
INSP. PITS
1, 7½ K.V.A. Lighting Trans.
3, No.0 Wires
NOTE: FOR ACCA SUB-STATION
Double Throw Circuit Breaker "D1-D2" Normally Operated With "D1" Closed and "D2" Open. In case of Failure of Va. Ry. & P. Cos. Transformer Sub-station, Throw Circuit Breaker so as to close "D2" and Open "D1". Then Feed from Boulton Generators
R.F.& P. Single Phase, 6600 Volt Signal Circuit
Circuit Breaker
Main Circuit Breaker
Primary Meter
Va. Ry. & P. Cos Mains 3 Phase, 2300 Volt 60 Cycle
2300 Volt Buss Bars
Automatic Circuit Breaker
3, 75 K.V.A. Trans.
2, 10 K.V.A. Trans.
TRAIN YARD HOIST
2, 10 K.V.A. Trans.
2000'
3, No.6 Wires
3, No.000 Wires
1, 125 K.V.A. Gen.
POWER PLANT
1, 150 K.V.A. Gen.
220 Volt Buss Bars
Note: FOR BOULTON POWER PLANT
Circuit Breakers "A, B and C" Normally Closed.
In case of failure of Va. Ry. & P. Cos. Supply Circuits to Boulton, Open Circuit Breaker "B" and Feed from Boulton Generators.
To Cut Out Boulton, keep "B" Closed and Open "A". To Cut out Acca. "B N" Tower and Broad St., Open "C"

General Layout of Power Lines of the Richmond, Fredericksburg & Potomac R. R. at Richmond, Va., Showing Arrangements for Emergency Service to all Facilities

The synchronous motor compressor set performs its function exceedingly well as practically unity power factor is obtained at the shop at all times.

Turntable

The 105 ft. twin-span turntable is operated by two General Electric 220-volt, 3-phase induction motors, one on either end. The method of supplying current to the turntable is by means of a set of overhead collector rings to which wires are run from a pole located near the edge of the turntable pit. On this pole are located two safety enclosed switches which are under the control of the operator of the turntable. The larger of these switches is for cutting off the power to the table if necessary for any reason and the second switch controls the floodlighting lamps which are mounted along the edge of the roof and are the source of light for the turntable operations.

Inspection Pits

The locomotive inspection pits are well arranged in the manner of convenience and illumination. There are two inspection pits and along their length, five lamps are installed in vapor-proof globes surrounded by heavy wire guards. The vapor-proof globe is an extra precaution against breakage of the lamps. These lamps are set in recesses so that no portion of them extends outside the surface of the wall. In addition to these lamps there are also plug outlets to which extension cords can be attached if desired.

Running between these two pits and also extending into the inspectors' building, which is located near at hand, is a tunnel through which it is possible for the inspectors to pass so that they may more readily reach the inspection pits. These tunnels cut through the pits about half way between two ends. For the external inspection of the locomotive there are a number of lamps mounted on poles close to the tracks and at a height which is convenient for securing the maximum illumination. The reflectors of these lamps are of the angle type so that most of the light is deflected where it is most needed.

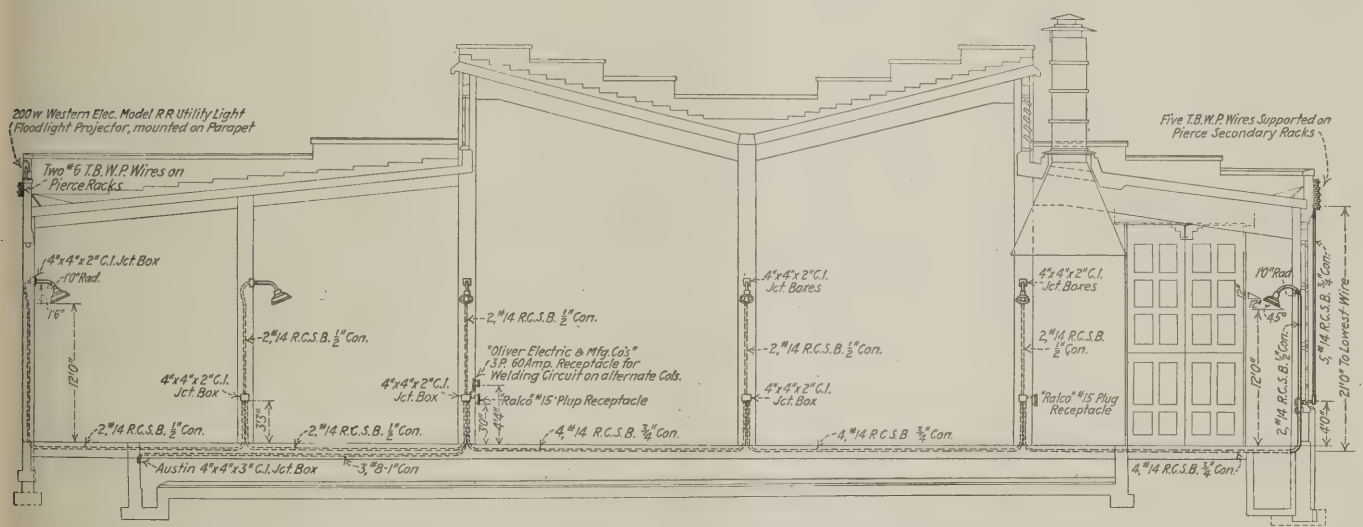
Coaling Plant

A concrete coaling plant of 1,000 ton capacity, constructed by Roberts & Schaeffer, is among the outdoor facilities. This plant is operated by 220-volt, 3-phase induction motors. The power supply is brought from the 2,300 volt line which runs along the north side of a railroad property. At a point opposite the coaling plant, the 2,300-volt line is tapped and led into three transformers which step down the voltage to 220 volts. At this voltage, the power is carried on three 350,000 circular mill lead covered cables running through a fibre duct under nine tracks to the motor house where by suitable Cutler-Hammer automatic equipment it operates the conveyors. In addition to these three power transformers there is a 7½ k.v.a. lighting transformer which is fed from one phase of the 2,300-volt line. This lighting transformer supplies current to a 3-wire system, the outer conductors of which have a difference of potential of 220 volts or 110 volts between either outside wire and the middle.

The lighting current is also carried in lead covered cables in fibre duct under the tracks and supplies lighting to the coaling station, oil and ice house.

Electric Traveling Hoists

One of the most useful electric appliances in the roundhouse is a Pawling & Harnischfeger electric hoist. This is a 6-ton hoist and is operated upon a 15-in. I-beam, the installation of which circles the entire building, approximately 10 ft. from the rear of the outer wall with switch leads to the drop pits and to the door opening on the material platform alongside the machine shop. Two of these hoists are provided. Each engine pit is served by two Cyclone bearing chain hoists of one ton capacity operated on 10-in. I-beams set 10 ft. 6 in. center to center and extending from the outer three bays to within 1 ft. 6 in. of the center line of the 6-ton hoist. In this way it will be seen that the 1-ton hoist can be used to bring material from the various stalls to the monorail, where it can be picked up by the 6-ton hoist and transported to any point desired.


200 w Western Elec. Model R R Utility Light Floodlight Projector, mounted on Parapet
Two #6 T.B.W.P. Wires on Pierce Racks
4"x4"x2" C.I. Jct. Box
10" Rad.
1'6"
12'0"
2"#14 R.C.S.B. ½" Con.
4"x4"x2" C.I. Jct. Box
2"#14 R.C.S.B. ½" Con.
33"
"Oliver Electric & Mfg. Co's" 1.3.P. 60 Amp. Receptacle for Welding Circuit on alternate Cols.
Ralco #15 Plug Receptacle
4"x4"x2" C.I. Jct. Box
30"
4'4"
2"#14 R.C.S.B. ½" Con.
4"#14 R.C.S.B. ¾" Con.
Austin 4"x4"x3" C.I. Jct. Box
3"#8-1" Con.
4"x4"x2" C.I. Jct. Boxes
2"#14 R.C.S.B. ½" Con.
4"x4"x2" C.I. Jct. Box
4"#14 R.C.S.B. ¾" Con.
4"x4"x2" C.I. Jct. Boxes
2"#14 R.C.S.B. ½" Con.
"Ralco" #15 Plug Receptacle
4"#14 R.C.S.B. ¾" Con.
Five T.B.W.P. Wires Supported on Pierce Secondary Racks
10" Rad.
45°
12'0"
2"#14 R.C.S.B. ½" Con.
5"#14 R.C.S.B. ¾" Con.
21'0" To Lowest Wire
4'0"

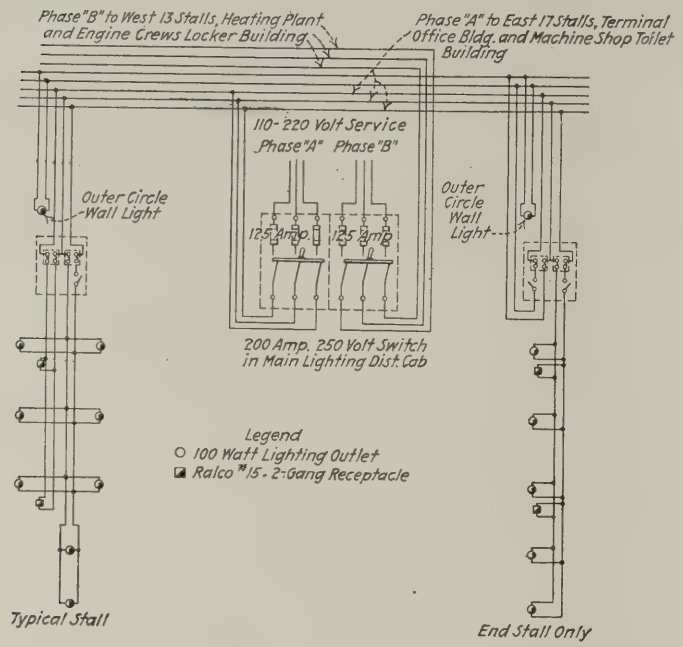
Cross-Section of Roundhouse Showing Arrangements of Conduit, Lighting Fixtures and Welding Receptacles

Conclusion

It is evident that the terminal is capable of effectively handling a much larger engine movement than it is now called upon to do and that the outside facilities have ample capacity to balance the increased size of the roundhouse when conditions require the building of additional stalls. Something of the future for which this capacity has been

provided in indicated by the fact that the northbound perishable movement, which now constitutes roughly one-quarter of the total freight tonnage of the road, has been doubling approximately once in every five years.

The new terminal was developed and constructed under


Phase "B" to West 13 Stalls, Heating Plant and Engine Crews Locker Building
Phase "A" to East 17 Stalls, Terminal Office Bldg. and Machine Shop Toilet Building
110-220 Volt Service
Phase "A" Phase "B"
Outer Circle Wall Light
125 Amp.
125 Amp.
Outer Circle Wall Light
200 Amp. 250 Volt Switch in Main Lighting Dist. Cab
Legend
100 Watt Lighting Outlet
Ralco "15" 2-Gang Receptacle
Typical Stall
End Stall Only

Circuit Diagram of Typical Stall and Special Arrangement for End Stall Only

the direction of W. D. Duke, general manager; H. J. Warthen, superintendent of motive power; L. Budwell, mechanical engineer, and E. M. Hastings, chief engineer. The plans were prepared and the construction carried out by the Arnold Company of Chicago.

British View Point of Radio on the Railroads

With so much public attention focussed upon wireless at the present time, its possibilities in railway work may usefully be considered. In the first place it should be pointed out that wireless communication for local purposes shows no advantage over the present wired means, although for long-distance work it is unrivalled. With few exceptions radio transmitting stations propagate their signals in all directions, and with this fact in mind, it will be appreciated that a large number of even low-power stations would overlap and interfere with each other. Thus the "wired" means is preferable, since it confines a message to one path only and with reasonable privacy. Directional wireless, in which the signals are projected in the form of a beam, although possible, is scarcely out of the experimental stage.

It is in cases of emergency, where the usual channels of communication are interrupted by storm, snow, flood, or malicious act, that wireless comes to the fore. This was realized during the railway strike of 1919 (England) when, it will be recalled, there was a grave danger that the whole industry of this country would be paralyzed, and that an effective means to that end lay in the hands of the strikers to cut the lines of communication to stop what little traffic was running. Seven important centres on the Midland Railway were equipped and in touch with one another by wireless telephone (Marconi ½-kw. portable sets) within a few days. Other railways were similarly to be equipped when the strike came to an end. At the end of 1920, also, wireless telephone tests were conducted between Euston and Crewe with successful results.

In the United States, where the railway telegraph lines in remote districts are exposed to severe weather conditions, the voluntary assistance of amateurs has been enlisted to maintain touch in case of need. These amateurs are properly organized and controlled by the American Radio Relay League, with whom the American Railway Association made the necessary arrangements.

Experiments have been made in telephoning to and between moving trains with some measure of success, although difficulty in obtaining reliable working has been experienced in eliminating unwanted noises arising from neighboring electrical systems, such as train-lighting installations and electrified sections of railways. Deep cuttings, tunnels, steel bridges and structures cause weakening of signals, besides atmospheric disturbances (so prevalent in the summer months and possible interference from other transmitters.

To save the cost of providing additional line wires, the carrier-current or "wired-wireless" system has been adopted in a few cases with advantage. In this system the existing telegraph or electric power lines serve as the path for the radio-frequency waves; one path, it might be added, will serve for several simultaneous duplex signaling or telephone systems. The expense of the system prohibits its use for short-distance work and probably accounts for the absence of a railway-owned installation. That vital unit in wireless apparatus, the thermionic valve, is finding increasing favor for ordinary telephone relaying work for trunk lines, while its possibilities in track-circuiting and other signalling work have been realized and several patents taken out relating thereto.

Although figuring so prominently in other branches of transport such as shipping and aviation, it will probably be concluded that no great scope in railway work exists in this country (England) for wireless communication, chiefly on account of the short ranges involved; but in other parts of the world where more remote districts are served by railway, it will undoubtedly find increasing use. Railway traffic control and automatic train control by wireless are well within the bounds of possibility.—*Railway Engineer (London.)*

Argentine railways are looking forward to another period of prosperity and progress. Reports of the British-owned lines for the financial year ended June 30, 1923, show successful results for the period, and the outlook for the coming year is encouraging, says Trade Commissioner George S. Brady in a report to the Commerce Department. Dividends on common stock for most of these roads were 7 per cent. Gross receipts on the principal roads were from 8 to 17 per cent higher than for the pevious year.

Many improvements were made and much equipment renewed during the year. In spite of heavy increases in service, the operating expenses of practically all lines showed a reduction from last year. On one of the largest lines—the Southern—this reduction reached 5 per cent, and on the Entre Rios 8 per cent.

Winding Standards for a Railroad Electrical Shop

A Course of Procedure for Repairing and Testing the Coils of Various Kinds of Motor Equipment

By Alfred C. Turtle
Shop Electrical Engineer, Canadian National Rys.

ALL windings whether starter, rotor or auto-starter units, field and armature units requiring repairs should be carefully examined and checked in order to prove the trouble as correctly diagnosed in the first place and also to make certain that such trouble is confined to and located as indicated in the first report.

The question of replacement or repair of the whole or part of such windings is dependent on the following conditions of the cotton covering on the magnet wire. If the fibre appears continuous, not perished, and a fairly good color such as light or ivory tan or between this and its natural new color, a small section of the winding can be safely replaced. If otherwise, such as insulation being dark tan in color due to subjection of windings to periods of high temperature or if cotton is found to be brittle and in a short fibrous condition (generally due to old age and dampness) it is usually unsafe or uneconomical to consider any but a complete rewind.

Careful supervision of such repairs and training of winders with the foregoing ideas in view will automatically bring shop efficiency to a reasonable level.

With winding insulation in fairly good condition the policy to be followed becomes more or less simplified, but the idea for economical operation demands that material that is in serviceable condition be used its full useful life before being replaced, except when obsolescence or other extreme causes require its replacement.

Urgency of repair where no readily available spare unit can be obtained may mean that the general practice as just outlined cannot be adhered to and that emergency repairs must be made no matter what condition the winding is in. If the cutting out of more coils than normally allowed is necessary, or a very patchy and incomplete job can be made which will allow machine to run long enough to make arrangements for a spare unit, then, by all means, use such methods on temporary work.

For permanent work definite standards slightly alterable to suit different dimensions and characteristics of machines as made by the different electrical manufacturers are necessary, and the following data should be used generally on such work.

Slot Insulations

Slot insulations to be of at least two unit—one of fish paper and one of empire cloth. Where dimensions are such that three units can be used, two fish papers and one empire cloth should preferably be used.

Minimum Total Thickness of Slot Insulation.

1 and up to 250 volts	.035 in.	35 mils
For and up to 500 volts	.045 in.	45 mils
From 500 up to 1,000 volts	.06 in.	60 mils
For 2,200 volts	.09 in.	90 mils

This refers to cotton, silk, paper and oiled cambric insulations only. Mica made up insulations can be used in place of above where reduction is necessary on account of slot space; such reductions not to be more than 10 mils in each case.

Projection of slot insulation beyond the laminations at each end should not be less than the following:—

Up to 950 volts service, ¾ in.; up to 2,500 volts service 1¼ in. Projection of insulation beyond the slot length this amount means that the first bend in coils will also be this distance away from laminations at least.

Phase windings on two or three phase motors should be separated at all crossings and end connections with 15-mil oiled cambric. Wherever two or more coil sides are in a slot as in diamond coil windings and particularly on double and triple circuit windings and coils of heavy cross section where a small number of turns are used in short pitch windings, extra insulations of not less than 15-mil oiled cambric should be used between such coil sides in the same slot. Full pitch windings will allow possible reduction to 5-mil oiled cambric or empire cloth.

Banding

Check armature winding and note tops of coils should project above core at banding grooves approximately 1/32 of an inch. This should be taken care of by the winder in the first case by proper insulation and if necessary by insertion of fibre strips in base of slot to bring coils to correct height.

Tension on wires to be approximately as follows, in pounds.

Dia. Wire Mils	*Core Bands*	*End Bands*
.03	...	...
.045	200	160
.064	300	230
.08	400	270

Solder with pure tin.
Flux. 1.5 lb. rosin dissolved in one quart wood alcohol.

Tin clips should be of sheet tin approximately .012 in. in thickness for small armatures, and .02 in. in thickness for large armatures. Each end of band wire should finish at a clip. Wind all bands at one time in continuous winding. Solder with iron only. One to three layers of 15-mil fish paper to be used under all bands, depending on size of armature and binding wire used.

Voltage Test on Unvarnished Windings

The following tests are those which have been tried and found suitable on one large railroad:

1. These tests do not necessarily have to be applied on parts not newly insulted, but do apply specifically to any complete or partial rewind newly insulated and not connected with old portion of partly rewound armatures for service on from 110 volts up to and including apparatus used on voltages not exceeding 600 volts.

2. A test voltage of 2,200 volts from each unit to ground shall be applied for a period of 60 seconds. A similar test must be applied between all phases as per the conditions previously set forth.

Apparatus used on lighting circuits of 120 volts, including induction motor secondary windings, and for all appliances used on circuits between 35 and 120 volts inclusive, shall be subject to a voltage test of 1,100 volts.

Apparatus used on 32-volt carlighting and locomotive headlight work including miscellaneous apparatus shall be subject to a voltage test of 550 volts.

All such tests shall be made in each case for at least a period of 60 seconds and at normal room temperatures.

The requisite test data for apparatus used on circuits of over 600 volts must be obtained from the office.

Commutators should be tested after being set and before armature leads are connected between segments with a pressure of 220 volts, *i.e.*, with the shop testing set only.

Commutators before being set should be tested with similar voltage and carefully checked and cleaned of all lappings and filings of copper or dirt on the interior surfaces.

Note.—In commutator setting heat must be applied until the segments reach a temperature of around 600 deg. F. Rings can then be tightened and should be followed up as the commutator cools off, care being taken not to strip the thread while doing this. If commutator is at approximate correct heat its surface will ignite a match on contact.

Varnishing and Drying

All completed windings should be dried out in an oven and brought up to approximately 180 deg. F. after which it can be well swabbed with clear baking varnish and returned to oven for 48 hours. Following this period a final swabbing with clear baking varnish will be given and the unit again placed in the oven for approximately 50 hours when the air-drying, oil-proof, black varnish can be applied.

Form wound coils for open slot work will require at least two separate dips and bakes of 12 hours each at 180 deg. F. before being taped. Two coats of air-drying varnish, after winding is finished will complete the treatment for this type of motor.

For ring wound armatures, two dippings in baking

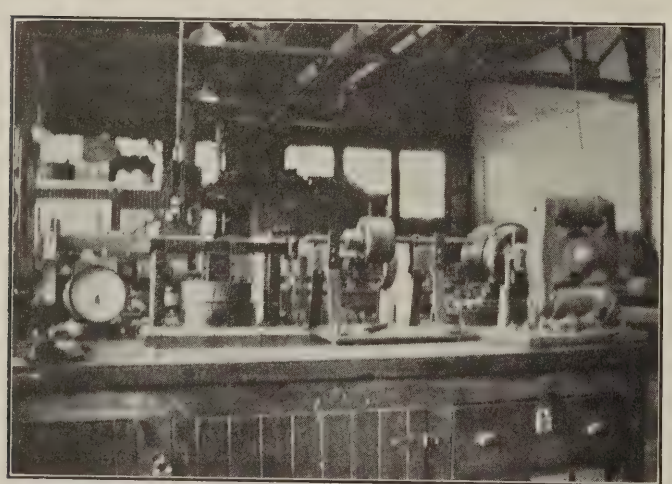


Fig. 1—Group of Testing Apparatus Developed Especially For Use in Connection with Headlight Generator Winding Tests

varnish with separate storing of 20 hours each and one final coat of air-drying varnish is found to be sufficient to complete the process.

On no account must 180 deg. F. be exceeded for baking coils, etc., unless permission specifically granted.

Care must be taken to avoid getting varnish on the laminated surfaces of revolving parts next to air gaps of revolving apparatus. The number of hours required for drying out the baking varnish is dependent on the size and mass of the apparatus being treated, therefore the figures given are only for the average sized units as follows:

20 hp. Induction motor, 900 r.p.m. stator
10 hp. Field, d.c. windings 200 volts
30 hp. D.C. armatures, 1150 r.p.m. 220 volts

A temperature as near to but not exceeding 180 deg. F. should be maintained in the oven when treating such windings.

Note that the baking varnish is used to exclude both air, dirt, moisture and oil, therefore interstices should be

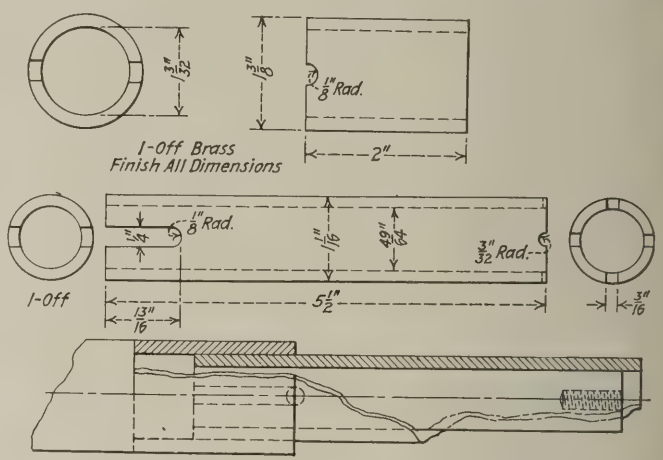


Fig. 2—Showing Method of Applying Bushings to Type "K" Shaft For Testing "E" Armatures on the Same Machine

filled as far as is possible in order to approach the ideal of a perfect winding.

In some cases where extreme urgency and lack of spare apparatus requires immediate replacement of rewound apparatus, it will be necessary to modify the heating and varnish schedule somewhat. Such cases can be taken up with the officer in charge and necessary modifications can be made.

Final Electrical Test

Induction motors to be assembled and if bearings, etc., have been passed on by millwright as satisfactory, to be put on test stand, belted to d.c. generator, connected to auto starter with voltmeter and ammeter in circuit and started up in the usual manner.

Run for one minute and in the case of phase-wound rotor note if rings are operating, then stop and check over all coils to note if any tendency for undue heating of any one or group of coils. If apparently satisfactory start again and load generator to half motor load. Check up again at end of one hour and if satisfactory repeat run at full load. For this test a rheostat is provided of ample radiating surface connected through controller which in turn is marked at its various positions for various horsepower input and in turn is checked by means of ammeter and voltmeter in circuit.

When this run is completed and temperature check taken, fill out the form showing the following data:

Horse power.
Number of slots.
Number of coils.
Speed characteristics.
Types of coil, diamond, basket, etc.
Pitch.
Number of turns per coil.
Size of wire.
Connection whether single, double, or triple circuit, etc.
Voltage.
Type and manufacture.

Machine used on.
Remarks as to balance of load tests.
Date.
Name of winder.

Headlight Generator Windings

The hard service and high speeds of equipment and the methods used in winding headlight generators to a large extent govern the type of test required to ensure the mechanical ability of the insulations to stand up. In the case of Pyle equipment which operates around speeds of approximately 4,200 to 4,400 peripheral feet per minute

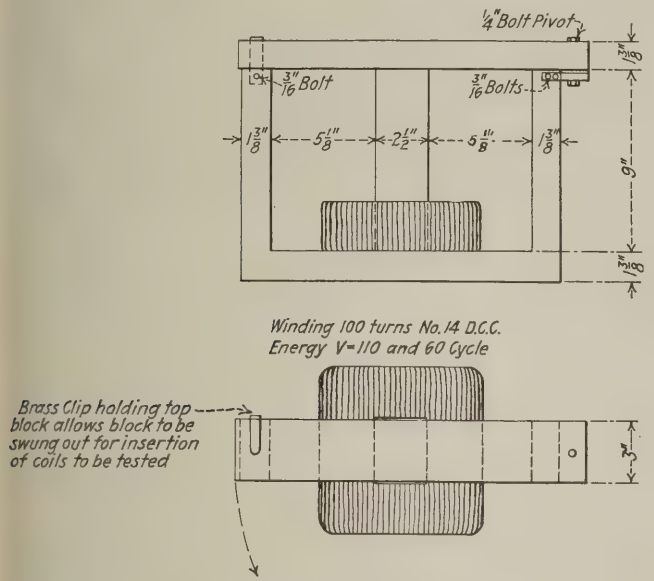


Fig. 3—Two Views of the Apparatus Used in Testing Coils

it becomes a very simple matter to install apparatus for making such tests.

To the right of Fig. 1 may be seen an old "C" type frame (Manchester Type) which is equipped with a mandrel as shown in Fig. 2, which allows the testing of both "E" and "K" armatures in the one machine. This is so arranged that it is possible to obtain speeds of from 2,400 r.p.m. up to 4,800 r.p.m. for mechanical and electrical tests.

Type "E" or "C" Armatures

The procedure is as follows: After a complete rewind each armature is set up in the test set and revolved at 3,600 r.p.m. or 5,657 peripheral feet per minute, in order to check the centrifugal action on the coils and commutator. If armature stands up without failure electrically; that is, without developing shorted or grounded coils, and mechanically without loosening up of commutator bars or throwing out of loosely wound coils, for a three minute run, the armature is o. k'd and then the varnishing and ovening duly follows. The test is conducted with a 70 watt load in the external circuit and the voltage is controlled by means of a field rheostat in the shunt field, thus avoiding excessive voltage on the lamps used for loading.

For "K" type armatures a test speed under the above conditions at 4,800 r.p.m. or 5,654 peripheral feet per minute, should be used, and is used on this machine, thus making a sure mechanical test.

Varnishing is accomplished by ovening until armature is in a heated dry condition. It is then dipped and baked for 24 hours, and the dipping repeated and a final ovening of 30 hours at temperatures not exceeding 180 degrees Fahrenheit.

A final test at normal speed is then arranged on the testing set over a period of 30 minutes at full load, or 500 watts.

Balancing of each unit is done on the "V" runways shown in Fig. 1 at the left of this testing set. The procedure is to first check up the "V" bars with a level and then set the armature on the shaft for this purpose (a separate shaft is provided for handling both styles of armatures when balancing).

If a trial shows the armature being tested is out of balance a strip of flat magnet wire is rolled in a small strip of insulating paper and driven firmly into the light sides of armature at the top of one of the slots. Where difference in balance is very minute a slight amount of lamination ground off the periphery of armature will correct same, but where balance can be corrected by using small strips as heretofore mentioned it is the sanest method to use such strips.

The final balancing of such apparatus should be done just prior to the final coat of varnish in all cases.

A diagram of the wiring arrangement of the test set, Fig. 4, shows the ground detector consisting of two 32-volt lamps in series, with the middle point connected to the frame of the machine. A flying or intermittent ground is often difficult to locate but will show on this apparatus which otherwise might not show under ordinary stationary voltage test.

The third object to the left in Fig. 1 shows part of a transformer core as used on regulator transformers for series arc systems. The old primary winding which was used originally on a 550-volt circuit is used as the exciting medium on a circuit of 550 volts alternating cur-

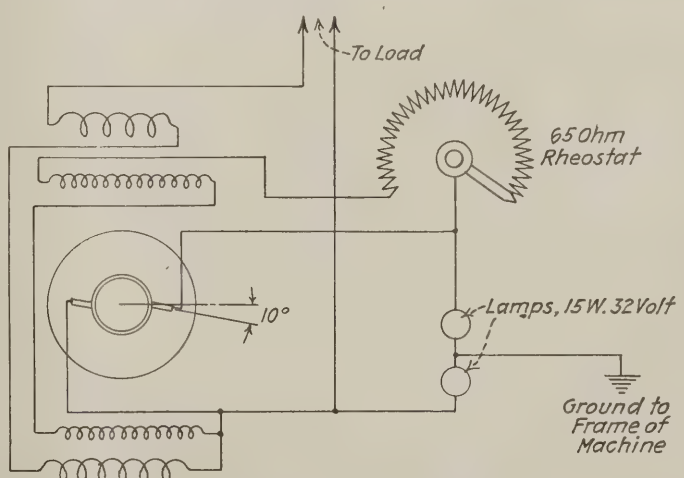


Fig. 4—Method of Checking Flying Grounds and Adjusting Voltage at High Speeds

rent. It is a very simple matter to slip on a field winding and connect its terminals to a 1,000-volt scale voltmeter and replace the upper section of laminations which are in block and open up on a hinge to allow the insertion of the coil to be tested. This is of great importance for checking old coils which have become possibly defective due to carbonization of insulation or infiltration of dirty oil and foreign matter. A period of one-half minute is the time that is allowed for the test on field coils on this machine.

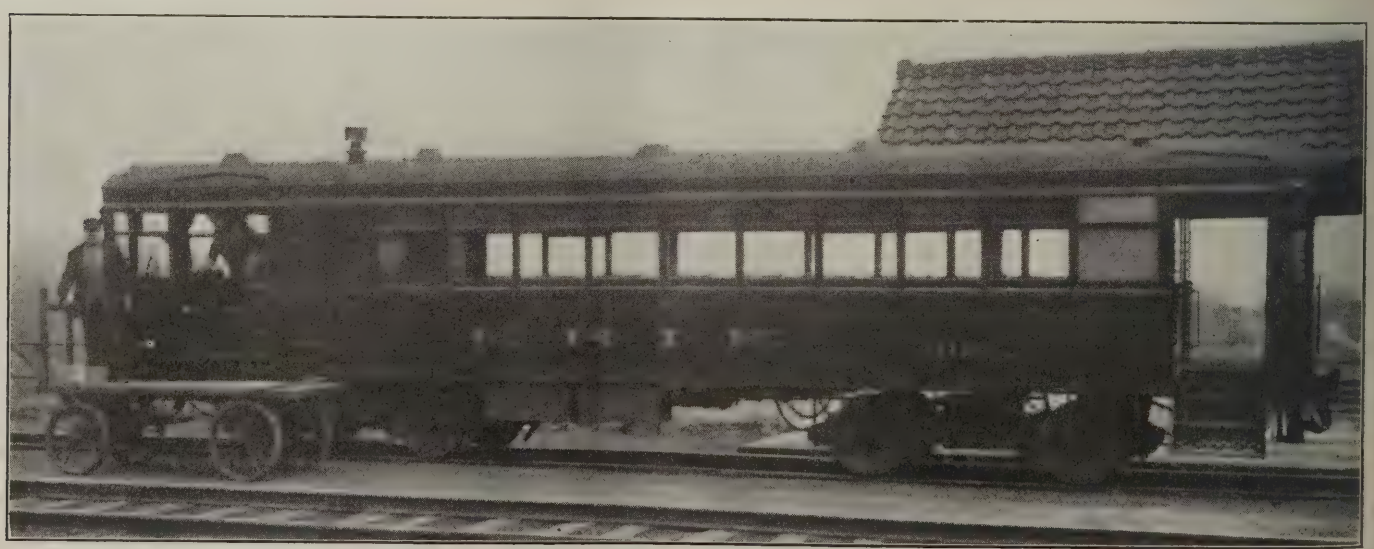
Harriman, N. Y., on the Main Line of the Erie Railroad

Erie Railroad Tries Out Rail Motor Cars

Several Months' Successful Operation Indicates Economic Solution of the Branch Line Problem

THE problem of furnishing passenger service between the main line of the Erie Railroad and the city of Newburgh, situated on the Hudson River, has long been a most perplexing one but the present indications are that a satisfactory solution has finally been reached. Newburgh is about 18 miles east from the connecting points of Harriman and Greycourt on the main line; Harriman being 47 miles out from Jersey City, the eastern terminal of the road, and Greycourt, 7.4 miles further west. The service maintained between these three points was all steam equipment until last October when two rail motor cars were put into operation and the steam service withdrawn. At times the traffic between these connecting points is very light and not infrequently it happens that there are no passengers at all. Obviously enough steam operated equipment was a relatively expensive proposition so far as passenger service was concerned, it was carried out only at a loss. The substitution of rail motor cars for the steam equipment has materially reduced the expense of operation and from the satisfactory manner in which these cars are performing, it would seem that the passenger transportation problem of this particular branch line had been solved.

Two steel cars built by the J. G. Brill Co., and using a gasoline engine built by the Midwest Engine Company, were purchased for the experimental installation. One of the cars was placed in service on October 1, 1923 and the other car on October 5. Little or no difficulty has been encountered in the operation of the rail cars since their installation. Regular engineers who had been previously



One of the Two-Rail Motor Cars Running Between Harriman, N. Y., and Newburgh, N. Y.

running on steam locomotives were broken in to run the new cars and all of these men speak well of the new transportation units.

At the present time, there are only two cars required for the service on this particular branch line but if future results continue as favorable as the past, there is little

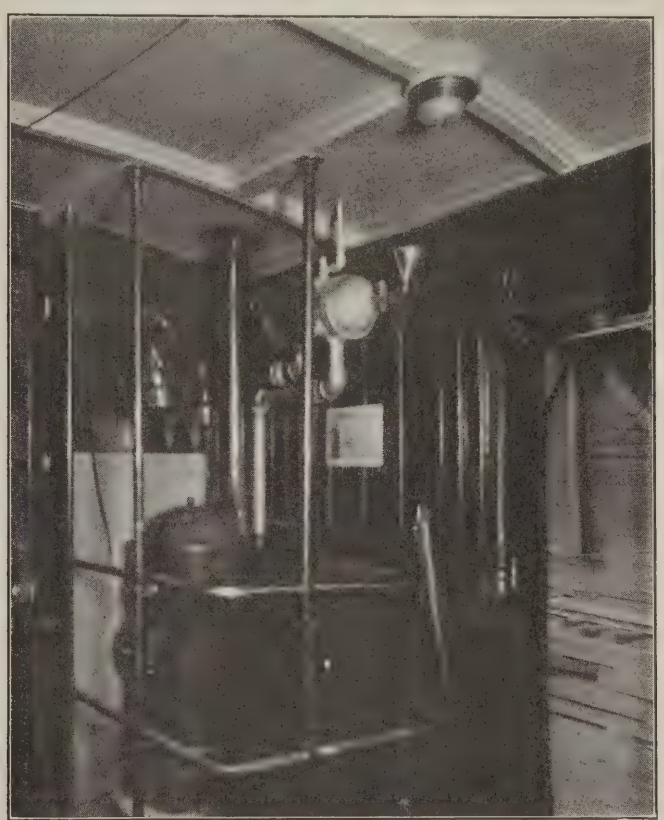
Front View of One of the Cars Showing Location of Bell, Whistle, Headlight and Classification Lamps.

doubt but that similar equipment will be installed on other branch lines where operating conditions are very similar. The cars are of steel construction mounted on two four-wheel trucks. The engine, which is located in the forward end, drives all four wheels of the forward truck

Interior of One of the Cars Looking from the Baggage Room Door

only, the rear truck being merely a trailer. The seating capacity of these cars is 38 passengers each and usually this is more than sufficient but on one occasion, one car has carried as many as 73 passengers without in any way affecting its speed. In fact, the motor which has a capacity of 75 hp., is claimed to be sufficient not only to maintain the rated speed of the car which is 48 miles per hour, but to pull a trailer if such is required and still maintain this speed. The geared shifts are operated by levers in much the same way as is the ordinary automobile except that there are more controls. There are five speeds ahead and five speeds reverse. A unique system of oil pressure is used under which the gears rotate, there being a film of oil between the gear teeth constantly so that the only metal to metal contact is found in the cylinder between the cylinder walls and the piston rings. The pressure required to operate this system is secured from the vacuum derived from the intake manifold.

Regular standard railroad safety equipment such as grab irons, steps, etc., are used throughout the construction. Two unique air whistles form a part of the equipment, one of these located on the front end of the car and



The Heating Unit Occupies but a Small Part of the Baggage Compartment

one on the rear. These whistles are horn-shaped in appearance and give a loud distinctive note readily heard for long distance. A locomotive bell is supplied on the front end only. This bell which is somewhat smaller than that used on a steam locomotive is operated by compressed air. The braking system used is the Westinghouse straight air brake type No. M 20 A, and this is supplemented by an emergency traction brake. Each car is equipped with front and rear sanders. Each car weighs 15 tons and is capable of traveling 150 miles on approximately 35 gallons of gas.

Lighting and Heating Installation

Illumination for the cars is supplied entirely by 21-candlepower 12-volt lamps, there being 10 of these located in the passenger section of the car and 2 in the vestibule at the rear over the steps. In the baggage end of the car

which occupies about 10 feet of the forward end, there are two of these lights. All of the lamps are mounted in half round enclosed glass domes in the roof of the car and are sufficiently near the passengers to give ample illumination for reading.

In addition to the lights for general illumination purposes, there are two lights for the driver, two marker lights in the rear and two classification lights in the front end as well as one 60-candle-power lamp used in the headlight. The two lights by the driver are used to illuminate the air gage and the instrument board. Upon this board are mounted four indicating devices which register respectively the oil pressure, engine speed, ampere charging rate and efficiency of the motor. The instrument which indicates the engine's speed is a most necessary adjunct since it tells the driver exactly the right instant at which to shift the levers during acceleration. In running down grade, or in drawing near stations on level track, the momentum of the car is sufficiently great to carry it over long distances at high speed, and under such conditions, it is possible and practicable to run in the neutral position in exactly the same manner as might be done with any automobile.

The efficiency meter is divided into four segments, cold, cool, efficient and hot and the pointer indicates clearly just what the condition of the meter is at all times.

The batteries consist of two 130 ampere-hour, 6-volt Exide batteries connected in series since all of the lighting is derived from 12-volt lamps. The starting and lighting system used is that designed by the Leece-Neville Company of Cleveland, Ohio.

The lighting is controlled entirely from snap switches located over the head of the driver, the different switches being used to control the different parts of the car such as the headlight, markers, classification lights; passenger and baggage sections.

The lighting system is protected against crosses or short circuits by one main fuse located in front of the driver. The headlight switch is of special construction being so designed that the headlight may be out, dim or bright as may be required. The heating of the cars is accomplished by means of a hot water system supplied from a small heater located in the baggage compartment.

The Driver's Seat Is on the Left-Forward Corner of the Baggage Compartment

The crew required for the operation of one of these cars consists of a conductor and driver, while on the other car, the crew is comprised of the conductor, driver and baggageman.

The Association of Railway Electrical Engineers will hold its semi-annual meeting on Thursday, June 12, at the Hotel Dennis, Atlantic City, N. J.

Ewing Galloway

Callao, Peru

Flexibility vs. Rigidity in the Design of Welds*

An Expression of Opinion by Several Welding Experts In So Far As Electric Processes Are Concerned

WHETHER a welded joint should be flexible or rigid is a question upon which some differences of opinion might be expected. At the recent annual meeting of American Welding Society held in New York a number of papers were presented on this subject. Only those processes which are electric are given here and abstracts of the papers presented before the society are as follows:

Carbon Arc Welding

J. C. LINCOLN, Vice-President, Lincoln Electric Co.

There is a great deal we do not know about what happens when a weld is made by the carbon arc process. The same is true of a weld made by the metallic arc process. There are some things we do know.

1. The heating of the metal is very rapid; as the arc progresses along the joint, the metal that is melted is

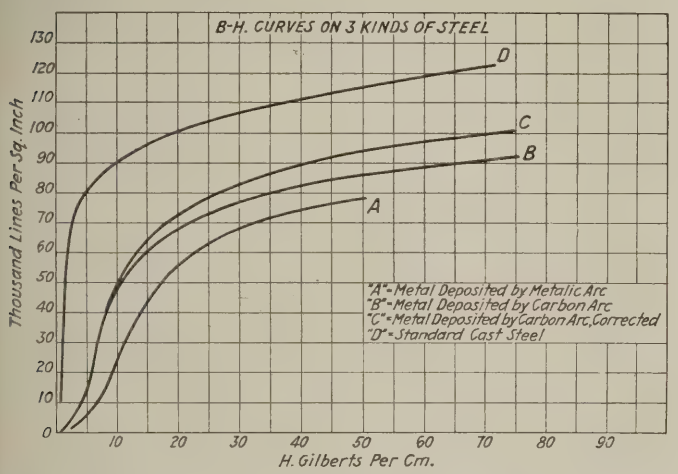


Fig. 1—Curves Showing the Relative Permeability of Three Kinds of Steel

raised from the room temperature to at least the melting point of steel in a fraction of a second. At this elevated temperature, some action takes place that propels the metal from one side of the crater to the other. The metal is propelled from the side of the crater that the arc is approaching to the side of the crater the arc is leaving. This force transfers from one side of the crater to the other 15 or 20 lb. of steel per hour when an arc of about 300 amp. is used under proper conditions. The action of the metal in a carbon arc, as well as the action of the metal in the metallic arc, can be explained on the assumption that steel at freezing temperatures or at the melting point dissolves large quantities of gas and that the capacity of steel to retain gases in solution decreases rapidly as the temperature of the steel is increased. As an analogy, the capacity of water to dissolve ammonia gas is very great at 0 deg. C., the melting point of water. At this temperature it will dissolve nearly 2,000 times its volume of ammonia gas. As the temperature of the water is raised its capacity for holding the gas in solution decreases until at the boiling point of water, practically all the gas has been driven out. The metal in both the carbon and metallic arc acts as if gas was evolved in or behind the heated metal and this acts as a blast to propel the metal from the hot side of the crater to the cool side, and from the metallic electrode to the work, even when the work is above the electrode as in vertical welding.

2. It is clear that in either the carbon or metallic arc the metal is raised in the fraction of a second, roughly 2,000 deg. C. It is also clear that the temperature of the metal after it has passed across the crater in the case of the carbon arc and across the arc in the case of the metallic arc falls with extreme rapidity. The rate at which the metal cools is much lower than the rate at which the temperature is raised, but even then the temperature of the metal falls with the same order of rapidity that the temperature of metal falls when it is quenched in water.

The practical question is what kind of metal have we in the weld after it has passed through the arc? The assumption is sometimes made that this metal is ordinary cast steel. In some respects this assumption is not justified by the facts.

The tensile strength of the steel after it has passed across the crater is almost equal to that of the original steel. Unfortunately, the ductility of the weld metal is not as great as the ductility of a good, ordinary cast steel. It is my opinion that improvement in the art of electric arc welding must be made in the direction of increasing the ductility of the weld metal. Another indication that weld metal is not ordinary cast steel is the fact that it will not stand up under prolonged heating at a bright red heat or above nearly as well as the ordinary steel casting.

Several years ago, in an effort to get additional information on the nature of weld metal, the writer had test samples made up from which the B-H curves could be made up. One sample was made of metal that had passed across the metallic arc and another sample of metal that had passed across the crater of the carbon arc. These samples were turned down so the final size was ½ in. diameter and 10 in. long. Mechanically the metallic arc sample was superior to the sample made by the carbon arc. There were a number of gas holes in the carbon arc welded sample which reduced the effective cross section at least 10 per cent. The samples were treated by the Case School of Applied Science and the results are shown in Fig. 1. Curve A is the B-H curve for the metallic arc sample. Curve B is the B-H curve for the carbon arc welded sample. Curve C is an estimate of what Curve B would have been if it had been free from holes and mechanically equal to the metal in Curve A. Curve D is the B-H curve for ordinary cast steel.

To my mind these curves show that the molecular structure of metal after it has crossed a metallic arc or passed across a carbon arc crater is quite different from the molecular structure of cast steel. It will be seen that these curves are similar to that of a pile of thin sheet iron discus made into a pile ½ in. in diameter and 10 in. high.

*Abstract of Papers Presented Before the Annual Meeting of the American Welding Society and published in the April Issue of the Journal of the American Welding Society.

It looks as if the iron particles were separated by something in the same way that the metal on the adjacent discs is separated by a layer of oxide. Attention should be called to the fact that the B-H curve for the carbon arc welded metal is better than for the metallic arc welded metal. My explanation of this fact is that the metal in passing from one side of the crater to the other in the carbon arc process is not heated to as high a temperature as the metal is heated in passing across the metallic arc. The practical result of all these considerations is that in the present state of the art we cannot expect metal of the highest ductility in the weld metal and that it is not to be expected that this metal will stand repeated bending as well as metal of a different structure and that, therefore, the welds must be made so as to throw any bending strains outside the weld.

In other words, the weld must be made rigid so that any possible bending will occur outside of the weld. Therefore, welds should be made rigid and not flexible.

Flexible and Rigid Methods in Preparing for Welding

I understand it is the general practice in gas welding to start the welding of two plates with an opening at the far end of the plates. As the welding proceeds these edges are drawn together by the contraction of the metal in the weld and plates as they cool. The same method is very often used in welding by the metallic process. What happens to a couple of plates when the edges are welded together depends on the expansion in the plates near the arc, due to the local heating. The strains set up by this local heating are hard to follow completely and it is likely that they are controlled by a number of factors. I will briefly discuss two factors which control to a great degree the strains in the plate and, therefore, dictate to a great degree the proper method of welding. It seems to me to be a safe statement that the locked-up strains in a weld are more largely due to the heating and cooling of the plates than to the cooling of the weld metal. The best study of locked-up strains in welds can best be made by

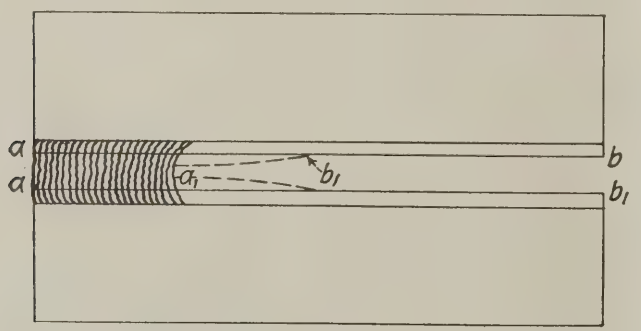


Fig. 2—Full lines ab Original Edge of Plate; Broken Lines a_1b_1 Edge After Expansion. The Expansion of Metal in Plates Ahead of Weld Draws Plates Together in Cooling

studying welds in cast iron. The volume of melted steel is about 7 per cent greater than the volume of the same metal cold. There is, therefore, about the same shrinkage in the weld metal when welding cast iron as when welding steel. The tensile strength of cast iron is about one-third that of steel. Therefore, a given strain in cast iron is three times as likely to produce a crack in the iron as in the steel. The greater ductility of the steel as compared with cast iron greatly increases this ratio. Experience in cast iron welding shows that heating of the edges of the plates to be welded must be reduced to the minimum in order to prevent cracking due to cooling strains. It is impossible to prevent the cooling strain due to the cooling of the melted weld metal, but experience shows that it is possible to do very difficult cast iron welding if care enough is taken to avoid excessive heating of the edges of the plates to be joined. This is done by welding half an inch or more and then letting the weld and plates cool before doing any more welding. The shrinkage of the weld metal is the same whether the cast iron is welded continuously or in short steps waiting for the metal to cool between steps. The local heating of the cast iron is less in the step by step method and the fact that the step

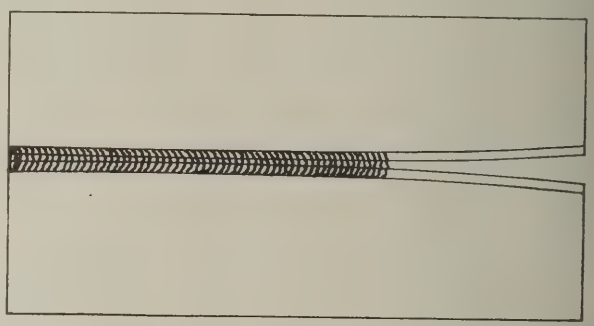


Fig. 3—Expansion of the Edges of the Plates Tends to Open Up the Plates at the Far End

by step welding produces a weld in cast iron less liable to crack indicates that the heating of the metal adjacent to the weld is, in this case, the determining factor between a good and a bad weld.

In the continuous welding of a joint between two plates there are two chief actions—one tending to close the plates at the far end of the weld and the other tending to open these plates at the far end.

Fig. 2 is a sketch intended to show that any heating of the edges of the plates ahead of the weld pushes this metal toward the other plate. After the weld is made, cooling of the plates, as well as cooling of the weld metal tends to draw the plates together and thereby draws the plates at the far end of the weld together. That this action exists is generally recognized by the common practice of leaving the plates farther apart at the far end than at the weld.

Fig. 3 shows what would tend to occur if the weld between two plates was made all at once as it is by the thermit process. In this case it is clear that the plates would have a tendency to open up at the ends.

It is evident that if the weld could be made quickly enough from one end to the other, that the same effect would appear. The question whether the plates tend to approach each other or to draw apart as the welding progresses is, therefore, determined by the *time* required to make the weld. If the weld is made slowly enough the effect shown in Fig. 2 will determine the result, for with slow welding, there is greater heating of the metal and, therefore, greater expansion ahead of the weld. Also, the expansion of the metal behind the weld becomes more general as soon as the heat is evenly distributed through the plate, and therefore, the effect shown in Fig. 3 decreases. On the other hand, making the weld rapidly decreases the heating, and, therefore, the expansion of the metal ahead of the weld, thereby decreasing the effect shown in Fig. 2 and at the same time increasing the effect shown in Fig. 3.

Experience with automatic carbon arc welding shows

that at a speed of about 1 ft. per minute the effect shown in Fig. 3 is greater than the effect shown in Fig. 2, and that the plates open up as the weld progresses. A sample which I have that shows this effect is about 3/16 in. thick and each plate is 3 in. wide and 20 in. long.

When the welding operation started the two plates were in contact. The ends are about 3/16 in. apart after welding.

The conclusion is, therefore, that if the right speed of welding is selected that the effects shown in Figs. 2 and 3

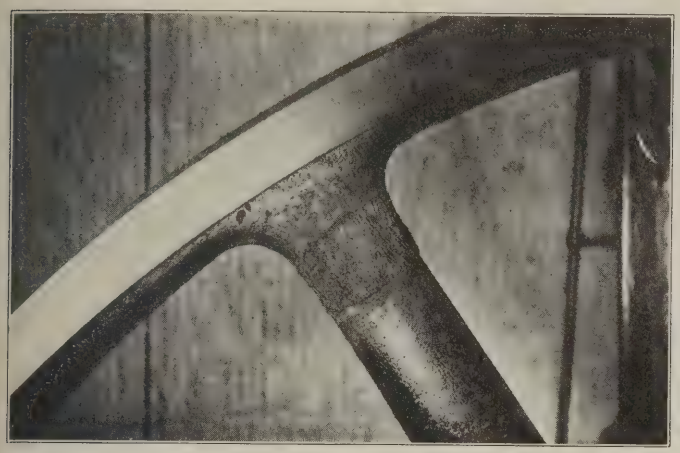


Fig. 4—A 14 ft. Fly Wheel in Which One of the Spokes Was Rigidly Welded in 1919 and Has Been in Constant Service Since

may be made to balance each other and thereby eliminate warping.

Metal Arc Welding

C. J. Holslag, Chief Engineer, Electric Arc Cutting & Welding Co.

This subject is so important a factor in the designing of a weld that it is thought necessary to devote specific attention to it. Shall a weld be made to absorb all the stresses of warpage and bending, or shall it be deliberately made to pass these on to the rolled or forged parent metal?

Let it be remembered that an electric arc weld is a casting and, fortunately, a very good casting. By means of improved methods the weld may even be refined to the point of exhibiting the physical and chemical characteristics of the best grade of electric steel castings, which are considered the best. Nevertheless, except in some special cases, it seems fairly obvious that the weld deposit should not attempt to compete in strength with the rolled plate. This plate, originally a casting, has been worked and rolled to a point where it has taken on properties which a plain casting cannot possess. An electric arc weld-casting is excellent as such, but cannot be classed with castings which have been rolled and worked. The same observation applies to any forged, stamped or pressed-steel member.

In spite of this, the process of arc welding affords a superior means of joining rolled plates or structural forms. In welding steel or iron castings, it seems apparent at once that the principal result desired is the production of a stiff, solid joint, and that the weld shall possess those properties of elongation and ductility found in a good casting. Under these conditions all parts of the weld should be capable of withstanding the contracting strains of the base metal. Although, in arc welding, these strains are usually very small, they may sometimes be sufficient to produce a faulty weld. This is especially true when the weld is made "cold."

However, if the weld cools without cracking, there need be no apprehension as to the presence of locked-up strains therein. As a matter of fact, the act of stretching steel beyond its elastic limit (although not beyond its ultimate strength) actually results in an improvement in its physical properties of ductility and elongation. If this is so, then the stretching of a steel weld beyond its elastic limit produces beneficial effects in the weld itself, so that no matter how much the weld is strained, if it cools without breaking it may be relied upon. Most welds that crack do so during welding, or directly after, while the piece is cooling. The reason for this is usually that a cross-section of sufficient strength to withstand the strains of cooling has not been provided. This brings us directly to the point to be emphasized, namely, that all electric arc welds should contain an adequate cross section and adequate stiffness, to be able to transfer all the strains which occur after cooling to the parent metal, which, supposedly, is better able to withstand these strains.

Although stretched steel is improved by moderate working, continued or intermittent stresses applied beyond the elastic limit will cause fatigue and complete loss of strength. Because of the fatigue tendencies of arc-welded steel, which are usually greater than those of worked metal, no live loads exceeding the elastic limit of the weld should be applied to it.

No riveted joint is designed to bend, and even the strongest of these joints—the double-butt strap—is certainly not capable of absorbing any of the bending strains within itself. This type of riveted construction is considered satisfactory for every use to which riveting is put; it would seem, then, that the same type of rigid construc-

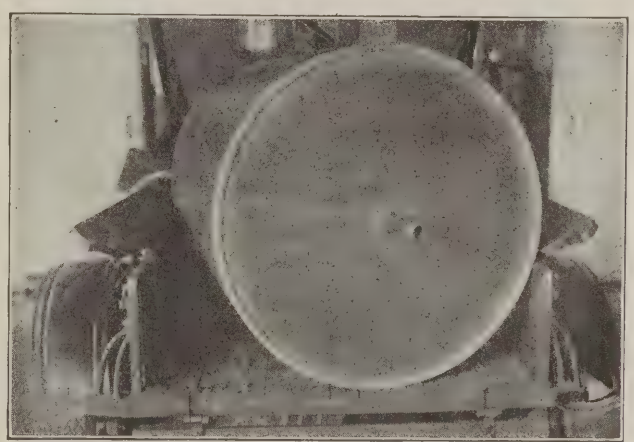


Fig. 5—A Cylindrical Tank with Head Rigidly Welded

tion would be entirely feasible in a weld. If this is so, the costly and unproductive research for a rubber-like welding material is scarcely justified.

However, let us suppose that such a material were available; an ideal material that would contain all the physical properties of the best forged steel. Even with the use of this wonderful metal, the cross section of a weld should be made as large as possible. Elongation and deformation in a weld should always be avoided, because the most perfect weld is apt to contain minute flaws. To preserve a consistent degree of excellence in every weld, it is best to divert all strains as widely as possible, and not to allow

them to be focussed in the weld. All castings are subject to the presence of blowholes, gas pockets and many other imperfections and should be treated accordingly. A steel casting may contain a jet-hole as big as a football and yet pass inspection; faults like these do not materially reduce the factor of safety. A poor weld casting is actually often better than a good poured casting.

**Sometimes in live-load welding an increase in cross-section is not permissible in the member. In this case an extra strong steel weld should be used, or some mechanical means should be devised to conduct the stresses to the metal outside the weld. Like any steel casting, the weld may possibly contain internal flaws, and the chances are that these will occur at or near the boundary between the welded and parent metal, unless both are of the same material. This condition is likely to result in the presence of a weak spot, under severe continuous or alternating stresses. This weak point may be eliminated by so designing the weld that the stresses will be diverted into the parent metal. In operations upon cast iron the steel arc weld is a better joining medium than the base metal; hence a weld of this type may be made to possess the capacity of absorbing *all* the cooling strains, and thereafter

Fig. 6—Exterior of Steel Vat Rigidly Welded

to hold the casting in its previous rigid state through a link stronger than the original metal. In cast steel welding all the physical properties of the parent metal are easily duplicated and a practically homogenous result assured.

In conclusion, we may assume that under advantageous conditions a weld made with average care will withstand the usual stresses with a strength about equal to that of mild rolled steel. Nevertheless, it is best to remember that a weld is a casting and always will be a casting, unless some method of forging is used. More progress may be made in the art of welding if its basic capabilities and limitations are frankly taken into account.

Resistance Welding

H. A. Woofter, Electrical Engineer, Thomson Electric Welding Co.

The service required by a welded joint determines whether or not the weld should be rigid or flexible. Welds in large machine tools, drill and reamer shanks, drill rods, rock drills and automobile and truck axles should be as rigid as the parent metal of the stock itself. The reason for this is apparent, for if the welded joint were more flexible than the parent stock it would be but a matter of a short time until crystallization would take place at the most flexible point, namely, the weld. In actual practice, however, the weld in such articles as quoted above is more rigid than the parent metal due to the pressure applied to push up the weld which compresses the metal, bringing the molecules closer together more in the nature of a drop forging. Consequently, axles, drill rods, drills, etc., which have been welded invariably break at some other point rather than the weld. We have broken axles coming into our job welding department, some of which show two or three, or even four previous welds which are still sound.

In welded joints in loom flyers, band saws, knife handles, mowing machine cutter bars, rug splitting knives, etc., the welds must be flexible because some of the articles are under an almost continuous bending movement, as, for instance, band saws, flyers and rug splitting knives. This flexibility can be secured by annealing the weld, preferably immediately after it has been made. This can be done by several different methods, and the particular method chosen should be determined by the requirements the article must meet in service. Welds in band saws are usually annealed immediately after welding in the welder itself by moving the clamping jaws somewhat farther apart than for welding, reducing the secondary voltage of the welder and heating the weld and sections adjacent thereto up to a dull red. In some cases one of such heatings is sufficient. In other cases, such as loom flyers, it is necessary to heat the piece in an oven and quench it in oil, sometimes as many as six times successively in order to secure the proper grain structure and flexibility in the welded joint. The great majority of resistance welds made in production require no annealing or quenching whatever. This is particularly true of the present practice in making automobile rims, truck wheels, bicycle frames, automobile cranks, farming implements, etc. All of the above come within the class of resistance welding known as butt welding.

Spot welds, in general, are not required to be flexible. The process takes the place of riveting, which is usually made as rigid as the riveter could make it. Seam welds, however, are sometimes required to be flexible in the plane at right angles to the face to facilitate rolling or forming, as in the case of barrels, containers, automobile bodies, etc. The welds in mechanical tubing, although made by the straight butt welding process, take on largely the nature of a seam weld, and as such are required to be flexible, in that the tubing must stand bending on a fairly small radius, as in the case of frames for beds, etc. It is also common practice to make a seam weld by a series of elongated spot welds. These welds must be flexible, as in the case of welded aluminum sheets or steel sheets, which are later drawn or pressed into automobile bodies, containers, etc. Welds in copper rods must be flexible, since the rods are often drawn into smaller sizes, sometimes into small wire.

**We mean by live load in this article loads under alternating stress, such as revolving members. The live load members in building construction are considered dead load for welding purposes.

Preliminary figures giving the United States exports of electrical goods for the first month of 1924 show a total of $7,652,215 worth of material shipped, an amount well above the average of 1923 and substantially greater than the exports for the same month a year ago.

Elementary Theory of Alternating Currents

A Series of Practical Articles Explaining a Difficult Subject in a Simple Manner

By K. C. Graham

Part II

Generation of Single and Polyphase Currents

THE classes of alternating current in common use are single-phase, two-phase and three-phase, the two and three-phase currents being known as polyphase currents.

The class of current generated in the single revolving loop of Fig. 2 is known as a single-phase current. The

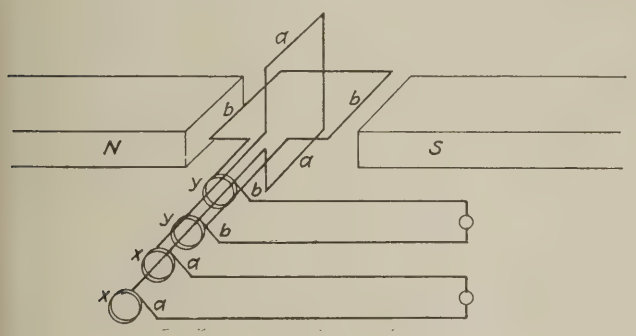


Fig. 12

reasons for these various designations will become more apparent shortly.

Fig. 12 shows two revolving loops *a-a* and *b-b* terminating in collector rings *x-x* and *y-y*, respectively, two separate circuits being taken from these two sets of rings. It will be noted that the planes of the two loops are 90 degrees apart, or at right angles, so that the two voltages generated in them are 90 degrees apart, as shown in Fig. 13.

These voltages, being 90 degrees apart, do not have

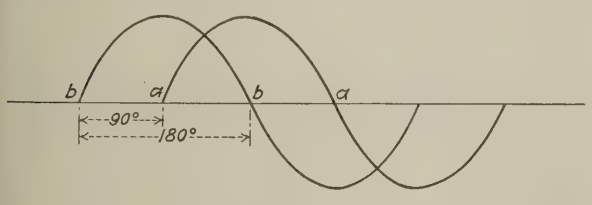


Fig. 13

their zero and maximum values at the same times, in fact, the voltage in loop *a-a* will be at a maximum when that in *b-b* is zero and 90 degrees later (one-fourth of a revolution) this will be reversed so that the voltage in *b-b* is maximum while that of *a-a* is zero. This illustrates the generation of a two-phase current and it is readily seen that it takes its name from the fact that there are two separate currents generated in the same machine. It must be remembered, however, that these two currents are always 90 degrees apart.

Fig. 14 (a) shows three equally spaced revolving loops terminating in three sets of collector rings. The three sets of currents resulting from the motion of the armature on which the loops are mounted may be considered as being either 60 or 120 degrees apart, depending on which conductor of loop *b* we look upon as being the beginning of the loop. If we choose b_2 the current through the various circuits will be 60 degrees apart. The selection of one or the other may be more readily visualized from a glance at Fig. 14 (b). Fig. 15 (a) illustrates this 60 degree relation of the three currents.

If b_2 is chosen as the beginning the phase relations of

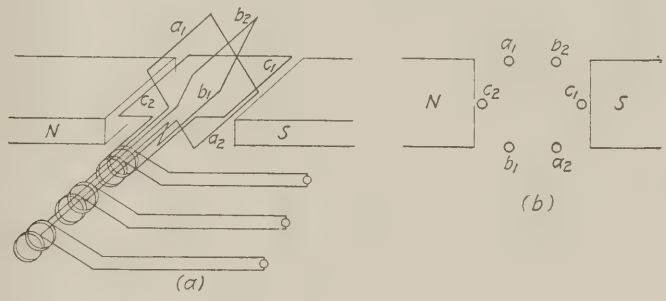


Fig. 14

the currents will be as shown in Fig. 15 (b). It is possible to eliminate three of the external conductors between the generator and the load by combining three of the generator and three of the load conductors in the proper manner. There are two ways in which this may be done and we shall take them up in order.

The most common method is the star or **Y** method. If we select the 60 degree connection referred to above we shall connect c_2 b_1 and a_2 together and a_1 and b_2 and

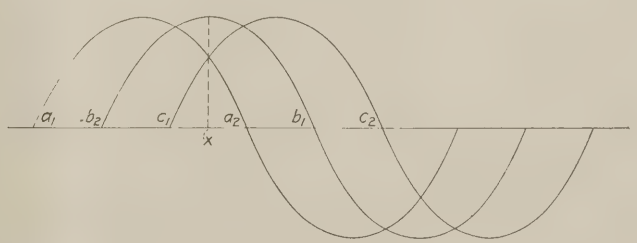


Fig. 15 (a)

c_1 to each of the three line wires that connect to the load. This is clearly shown in Fig. 16 (a), but may be more easily visualized upon reference to Fig. 16 (b), which shows the connections between the collector rings and the load. It will be noted that the load is also connected so that there are only three wires from it to the generator. As mentioned, in regard to generators, there are also two

ways in which the load may be connected to bring this about. The method of connecting the load shown in Fig. 16 (b) is designated as star or **Y** just as in the case of the generator. The waves of voltage generated in the three loops will then be only 60 degrees apart as in Fig. 15 (a). It will be noted that the voltages in the three loops are all in the same direction during a considerable portion of the cycle, this being denoted by the fact that they are all on the same side of the line the greater part of the time. This will result in the condition marked at x in this same figure where it is seen that the voltage of

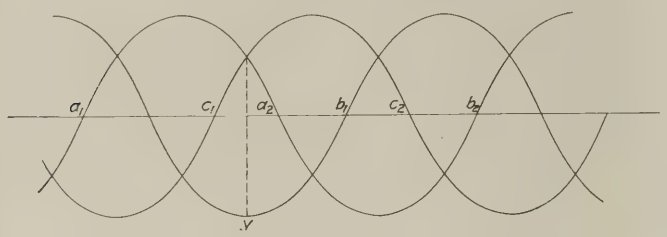


Fig. 15 (b)

loop b is maximum while that of the other two loops is about 50 per cent of maximum, and they are all opposed to each other as shown in Fig. 16 (c). Due to the fact that the voltages in loops a and c are less than that in b a current will be forced through these two in opposition to the direction of the voltage generated in them. This will bring about a very unsatisfactory condition of current flow in the external circuit, the voltage will be unsteady

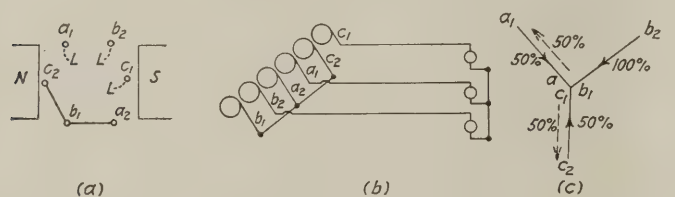


Fig. 16

and of a very low value. Therefore, we may conclude that the 60 degree combination is unsatisfactory and we shall proceed to the study of the 120 degree method.

This method is illustrated in Fig. 17 (a), which shows a_2, b_2 and c_2 connected together while each one of a_1, b_1 and c_1 are connected to one of the line wires. Fig. 17 (b) needs no further explanation, but Fig. 17 (c) shows a condition very much different from that of Fig. 16. It

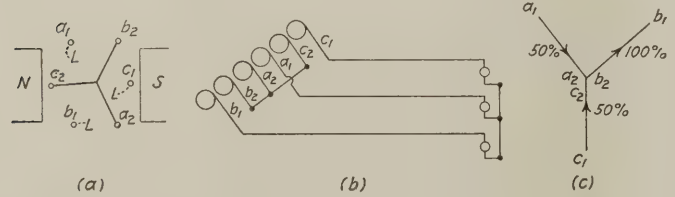


Fig. 17

will be noted in Fig. 15 (b) that there is no point in the cycle when all three of the waves are above the line or, in other words, there is no point in the cycle where the three voltages are in such relation that they all oppose one another. As a matter of fact it may be readily seen that two of the loops are on one side of the line while the other one, on the other side of the line, generates a voltage equal to that of the first two. If a current flows through the circuit the one loop acts as a return path for the current in the other two so that the current flowing through the external circuit is maintained at a steady value. This also applies, of course, to the voltage, the value of which,

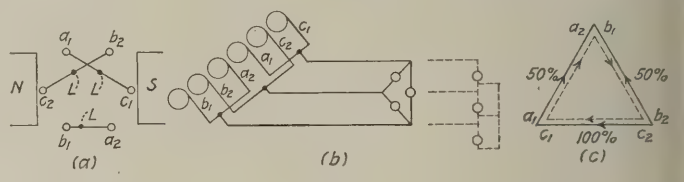


Fig. 18

between any two line wires, is steady or *constant* as it is called.

The second method of grouping the conductors is illustrated in Figs. 18-19. This is known as the delta connection. Fig. 18 (a) shows a_1 connected to c_1, b_2 to c_2 and a_2 to b_1, each of these three pairs being connected to one of the line wires as in Fig. 18 (b). It will be seen that the load is also connected in this way, although this is not necessary because the functioning of the system will be the same however the load may be connected, and it would be possible to have the load connected as shown by

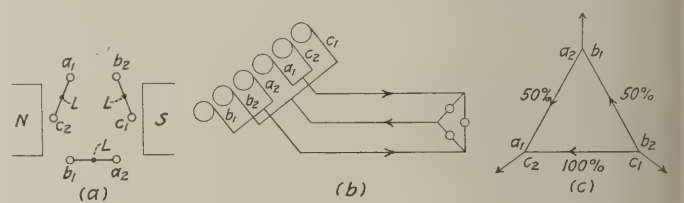


Fig. 19

the dotted lines. It would also have been possible to have connected the load delta in the previous figure where the star connected generator was considered, without affecting the operation of the system. The point that it is desired to bring out here is that the generating and consuming branches of the circuit are independent of one another insofar as their individual methods of connection are concerned. The particular delta connection shown here results in a 60 degree phase relation as in Fig. 15 (a) which in turn results in the condition shown in Fig.

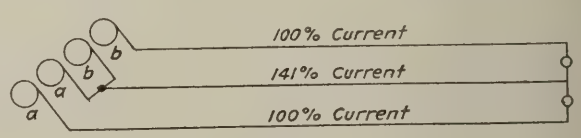


Fig. 20

18 (c). Here it will be seen that an internal current will flow through the windings without passing through the external circuit because at point x Fig. 15 (a) the voltage relations are such that the voltage in loop a opposes and neutralizes that in b so that the full voltage of loop c is effective in forcing current through the internal circuit. This is very clearly shown in Fig. 18 (c). Thus the impossibility of using the 60 degree relation applies to the delta connection just the same as in the case of the star connection.

Fig. 19 (a) shows the coil terminals grouped in a somewhat different manner and it will be seen from Fig. 19

(c) that the net result is the elimination of the internal current referred to in Fig. 18 because the voltages of two of the phases are at all times opposing that of the other phase, their sum being equal to the voltage of this other phase. Thus a process of continual rotation of the position of this resultant condition, takes place; *a* and *b* oppose *c*, then *b* opposes *c*, while *a* passes through the zero point on the cycle curve, then *a* and *c* oppose *b; c* becomes zero and *b* opposes *a; b* and *c* oppose *a; b* becomes zero while *a* opposes *c* and again *a* and *b* oppose *c* so that throughout the whole cycle the voltage relations are such that any tendency for an internal current is suppressed. Although the internal voltages are in opposition they combine to force current through the external circuit as shown in Fig. 18 (b) and it should be noted that one of the wires acts as a return for the other two as in the case of the star connection.

It is because of the return circuit feature of the 120 degree relation that it is chosen for the three-phase circuit. The advantage of using only three wires to supply the same amount of power as is normally supplied by means of six wires is so apparent that it hardly needs to be discussed in detail when initial cost and future maintenance costs are considered.

It may be mentioned in passing, that it is possible to supply two-phase power by means of three wires rather than four, but very little saving is occasioned by doing so. In this case one end of each of the two phases are connected to a common conductor as in Fig. 20, which carries the combined currents of the two phases. These currents being at 90 degrees to each other result in a common wire current the maximum value of which is almost 50 per cent greater than that in either of the two outer wires so that the common wire must be about 50 per cent larger than the other wires and the saving in copper is very small as compared to the saving in copper occasioned by use of the three-phase circuit. The three wire two-phase current is also very unpopular in some sections of the country, the four wire system being almost universally used where two-phase current is used at all. Furthermore, it is certain that in the not far distant future two-phase current will be entirely replaced by three-phase power because of the saving in copper just mentioned.

Commutator Slotting*

By A. E. Pratt
Manager Railway Sales Division
National Carbon Company, Inc.

COMMUTATOR slotting, also called grooving or undercutting, consists in removing the mica from between the commutator segments to a slight depth, generally about 1/32 in. or 3/64 in. below the surface of the commutator. This leaves only the copper in contact with the brushes.

This practice, tried in isolated cases twenty or more years ago, did not come into general favor until about 1905, when its economy for railway motors was definitely established. Within a few years about 90 per cent of the railway motor commutators were undercut. It is surprising that the practice did not spread immediately to industrial motors and generators, but for eight or ten years only a slow development took place, except in a few industries, such as the steel industry. For the past two or three years commutator slotting has been gaining favor in the industrial field almost as rapidly as it did years ago in the railway field.

On undercut commutators, brushes with very low friction and without any abrasive action can be used, while on flush mica commutators brushes with sufficient abrasive action to prevent the mica from becoming high must be used. This not only means commutator wear but as it is impossible to get abrasive action without relatively high friction it also means greater heating of the commutator and a corresponding power loss. The friction loss with an abrasive brush operated at 2 lb. per square inch pressure on the average machine will be about 2½ per cent of the machine's capacity. On a 100 kw. generator operating 10 hours per day 300 days per year with a power cost of 1½c per kilowatt hour, this friction loss means 2½ per cent of 300,000 kw. hours, or $112.50 per year. Most of this expense can be saved by the use of the proper brush on a slotted commutator.

Other advantages of undercutting are increased life of commutator and brushes, elimination of flat spots, sparking, glowing of brushes and burning of commutator as well as decreased heating which permits an increase in the load of the machine.

There are many methods of undercutting in use. Standard undercutting equipments consisting of circular milling saws driven by some convenient means are put out by several manufacturers. Two or three hand tools are also on the market. Of these, the commutator slotting file probably is easiest to operate and does the best work. A properly ground tool operated with the tool carriage of a lathe does satisfactory work. Broken hack-saw blades are also frequently used for undercutting.

When slotting a commutator great care should be taken to see that no strips or particles of mica are left flush with the commutator surface. Where undercutting has been found unsatisfactory it has nearly always been due to this defect or to the use of improper brushes. After undercutting with the milling saws, lathe tool or broken hack-saw blade it is advisable to run over each slot with a sharp V-shaped tool or commutator slotting file and slightly bevel the edge of the commutator bars to make sure that the slots are free from mica and to remove burrs of copper left by the slotting tool.

If the commutator is eccentric or has flat spots it should be turned or ground before it is undercut. Instructions for turning and grinding will be published in another issue.

After the mica is undercut the commutator should be polished with a commutator stone or a very fine grade of sandpaper attached to a block rounded to fit the commutator. The commutator stone is better as it leaves the commutator free from scratches. This is important, as the brushes to be used on an undercut commutator have no abrasive action and therefore cannot polish out any scratches that are present.

Lubricants should not be used on undercut commutators, as they will hold carbon dust and other dirt in the slots and may cause short circuits and burned out coils. If proper low friction brushes are used there is no need of further lubrication.

Where oil may creep in from the bearings or where the machine operates in a very dirty location, it is advisable after slotting to paint the slots with air-drying insulating

*One of a series of short articles on carbon brushes.

varnish, and after this is dry it should be removed from the surface of the commutator with sandpaper or a commutator stone. It is advisable to occasionally clean out the slots. Care should be taken in undercutting to see that the slots are not made too deep. From 1/32 in. to 3/64 in. is recommended.

Perhaps the most important precaution of all is to see that proper brushes are installed. If abrasive brushes were used on the unslotted commutator and are put back on the slotted commutator they will quickly wear it down, fill up the slots with copper dust and probably cause short circuits and burned out armatures.

The brush pressure is also important and for slotted commutators under the average conditions from 1¾ to 2¼ pounds per square inch of brush contact surface for stationary motors and generators is recommended; 2 to 3 pounds for elevator and mill type motors, 3 to 5 pounds for crane motors and 4 to 7 pounds for railway motors.

For average conditions the following brushes may be used for undercut commutators:

High speed rotary converters and turbo-generators above 5,000 feet per minute peripheral speed—No. 257 or No. 634.

Stationary motors, generators and rotary converters with peripheral speed under 5,000 feet per minute—No. 255.

Mill type and elevator motors—No. 401.

Crane motors—No. 401 or No. 407.

Railway motors—No. 203, No. 222, No. 255, No. 401, No. 402 or No. 407.

Local conditions frequently alter these general recommendations, and it is often desirable to have the engineers of the brush manufacturers select the best grade for your service.

Electric Glue Pot with Thermostatic Control

Tests have demonstrated that animal glue, in order to retain the constituents that give it maximum adhesiveness, must be carefully handled in heating. The temperature of boiled water, 212 deg. F., is much higher than the critical temperature of glue, which is about 155 deg. F. At this temperature glue begins to break up and, by evaporation, loses its most valuable elements, and at 185 deg. it has practically lost its value as an adhesive. The best working temperatures for glue are between 140 deg. and 150 deg. F. to provide a safe margin to allow for the temperature drop, which follows the introduction of a cold brush into the glue pot. Unsatisfactory work is bound to follow the use of under or over-heated glue and, in order to meet these requirements, the Van Dorn Electric Tool Company, Cleveland, Ohio, has placed on the market a water-jacketed, electrically heated glue pot with a thermostatic control which keeps the glue at the correct working temperature. It is made in one size only, with a pot of two quarts capacity.

The glue pot is of cast aluminum with the rim machined to give an air-tight fit on the water pot, in order to prevent loss by evaporation. A drip ring returns all condensation to the water pot. The water jacket is a gray iron casting, ground to an air-tight fit with the glue pot. The outside of the water pot telescopes over a rim on the base, preventing any penetration of water to the heating element when refilling the pot. The necessity for replenishing the water occurs only at long intervals. By actual test, these glue pots have operated for three weeks before additional water had to be supplied.

The heating element consists of a nichrome ribbon, insulated by mica plates, and is moisture proof. Easy replacement of the heating element or of the automatic control is made possible by the simplicity of its construction. The crowned base presses the heating element solidly against the bottom of the water pot, to insure a perfect thermal contact. An asbestos plate and air chamber in the base adds to the heat insulation and tends to prevent

Glue Pot Designed to Maintain Automatically the Correct Working Temperature

any loss by radiation downward. The current consumption is low and the device is economical to operate.

The thermostatic control provides positive heat control that will hold the temperature of the contents of the glue pot at 150 deg. F., with a variation of less than 5 deg., regardless of room temperature. The thermostat is set at this point and is fully tested before the glue pot leaves the factory.

The device can be operated from an ordinary electric light socket, and it is equipped with a cable and separable plug. Its simple construction is shown by the cut away portion of the water jacket.

Manufacture of electrical generating apparatus and telephone and telegraph cables was added to the list of established industries in Australia during 1923, Consul N. L. Anderson reports. A company in New South Wales has been engaged in making an 18,750 kw. turbo-alternator and is beginning to work upon another machie of the same size. This is the first udertaking of this magnitude in Australia of this class of machinery.

Early Electric Operation on the New Haven

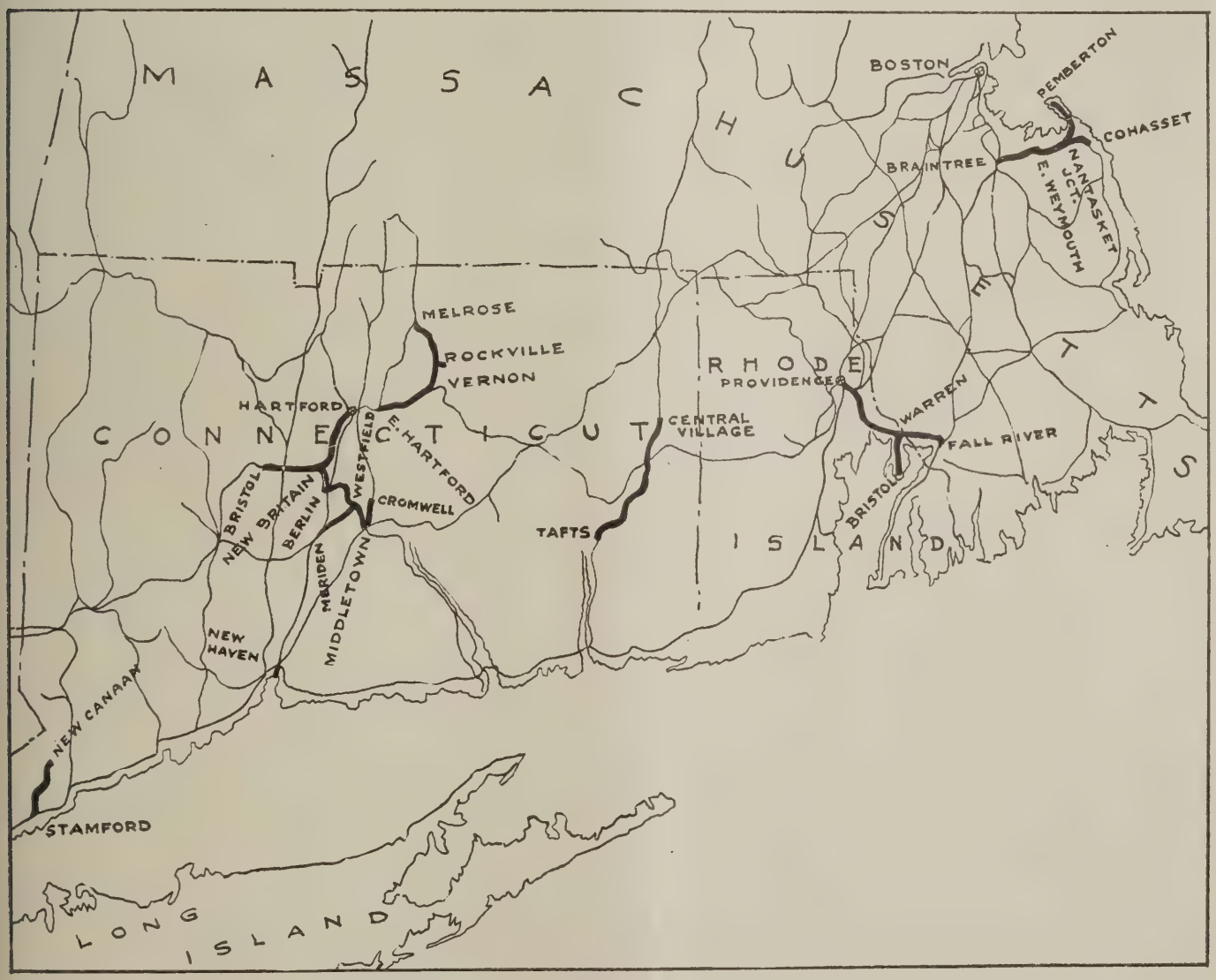
An Historical Account of the Beginning of Electric Traction as Applied to Steam Railroads

By Sidney Withington
Electrical Engineer. New York, New Haven & Hartford R. R.

THE New York, New Haven & Hartford Railroad was interested very early in electric operation. In 1891 President Clark called attention to the large place that electrification would probably take in steam railroad operation. The competition from trolley cars in the early nineties showed signs of presenting a serious situation, and the management felt that the problem would best be met by electrifying, and operating a service as closely as possible competitive with the trolley companies which paralleled the right-of-way. It was also thought that the experience gained in branch line service would be of great value in subsequent main line electrification.

On June 30, 1895, electric operation on the Nantasket Beach Branch was inaugurated. This is a branch about nine miles long, extending from Nantasket Junction to Pemberton, Massachusetts, on which the summer traffic is extremely heavy. This initial operation was the first example of electric power applied to steam railroad operation in this country, antedating by a few months the electric operation of the Baltimore tunnel of the B. & O. Railroad.

The power distribution was by means of a 330,030 c.m. overhead trolley, weighing approximately one pound per foot. The section was a figure "8" with the lower side somewhat flattened, rolled specially for the service by J. E. Roebling. Much of this wire is still in service. The wire was directly suspended from double brackets, the poles being between the tracks, which were spaced on fifteen foot centers. The poles were sawed hard pine



Map Showing the Early Electrified Sections of the New York, New Haven & Hartford Railroad

12 in. by 14 in. at the butt and 10 in. by 12 in. at the top, set in concrete. The brackets consisted of two pieces of angle 2 in. by 3 in., supported by ½-in. round iron truss rods through a cast iron cap at the top of the pole. The feeders were supported on this cap in grooves, without insulation other than the wood pole itself, and operated in this way for a great many years.

The power was furnished from a power plant (constructed for this operation) by two tandem compound Greene engines, operating at 110 r.p.m. and rated at 1,420 horsepower each. The generators were rated at 500 kilowatts each and the station voltage was 700 volts. The steam plant was operated until 1920, when it was discontinued and power purchased from the Weymouth Light & Power Company. The building is now a substation.

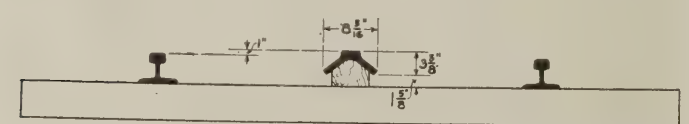
The original equipment consisted of ten motor cars, of which six were open and four closed, together with a number of trailers. The motor cars weighed 60,000 pounds and the trailers 43,000 pounds. Each motor car usually hauled three or four trailers. Much of this equipment is still in service.

The annual report to the stockholders in 1895, in referring to the electric operation, contains this statement:

"The experiment has demonstrated that power generated in a stationary plant and transmitted by electrical energy can be successfully used in the operation of a standard railroad. The current expenses for fuel indicate that this result is economically obtained. . . .

"The use of the existing power station will be extended presently, and it is probable that electricity will be promptly adopted by the company at other points on its lines. With a road free from grade crossings, it is not too much to expect its ultimate application wherever the business justifies frequent train service, and it is to be hoped without the use of an overhead trolley."

The idea of a third rail distribution had long been in mind, and the second step in the electrification of this railroad was undertaken on July 26, 1896, when the electric operation of the Nantasket Beach Branch was extended three and one-half miles to East Weymouth. The power distribution on the extension was by means of a third rail instead of overhead. This was the first time in



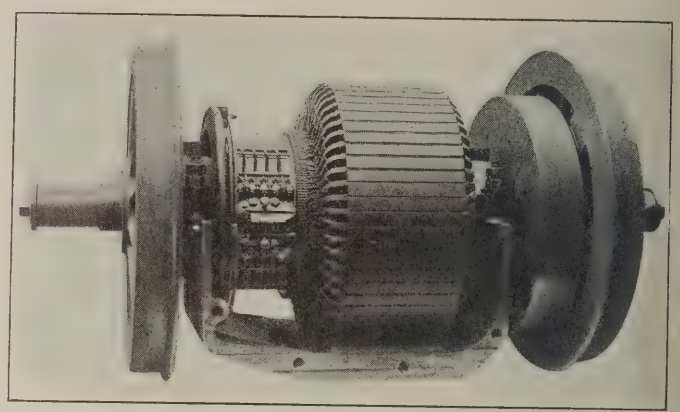
Third Rail as Installed Between Hartford—Bristol—Berlin (Connecticut) Braintree—Cohasset (Massachusetts)

the history of railroads that a surface railroad was operated electrically from a conductor laid "on the ground," just as in the year before the operation on the Nantasket Beach Branch was the first application of electricity for the sole motive power on a section of standard steam railroad.

The third rail was in the form of a flattened "A" and was installed midway between the track rails, supported at ten foot intervals on treated ash blocks set on the ties. This rail, which weighed 93 pounds per yard, was designed to shed water and protect the wooden blocks which supported it. The top of the third rail was one inch above the top of the running rails and its lowest point 1⅝ in. above the ties. The contact was thus high enough so the shoe cleared the rails at turnouts, cross-overs, etc., but not high enough to foul steam equipment which necessarily operated over the electrified tracks.

The splice plates for the third rail were wrought iron 12 in. by 4½ in. by ¾ in., and between the splice plates and the third rail were ⅛ in. copper plates acting as bonds. Sixteen bolts were used at splices. Wood blocks bevelled at the ends assured that the shoes would ride up over the third rail.

At gaps in the rail at cross-overs and turnouts, street crossings, etc., 850,000 c.m. jumpers were installed between sections of rail in creosoted wood ducts, which were filled with asphalt compound, the whole laid in creosoted



Armature of the Manufacturers Railroad Motor Mounted on a Drum Axle

wood troughs and filled with the same compound. The connections to the third rail were sweated and bolted.

The track bonds were 550,000 c.m. leaf bonds fastened under the flange of the rail by means of expansion pins or wedges driven in from the top. It was determined at that time that the leaf bonds were better than copper cable.

From East Weymouth to Pemberton, a distance of ten and one-half miles, seven miles of which was overhead trolley construction and three and one-half miles third rail, a 64-ton train making thirteen stops reached a maximum speed of about 37 miles an hour between stations and maintained an average speed of 17 miles an hour. A maximum speed of 57 miles an hour was attained by the express trains.

In the summer of 1896 six thousand train miles were made and 700,000 passengers were carried electrically on this electrified section.

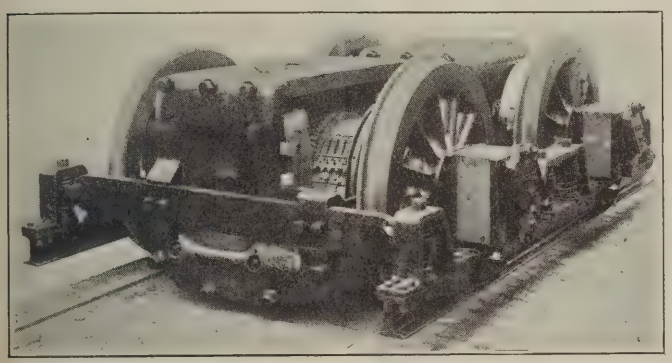
The third rail was apparently quite satisfactory in its operation—perhaps more so than the overhead trolley—and very little criticism was offered; the public apparently, at first, at any rate, kept away from the rail and no damage or injury claims occurred.

In December, 1896, work on the electrification of another section was started between Hartford and New Britain (9.3 miles) and between New Britain and Berlin (3 miles), a total distance of 12.3 miles. The power plant was located at Berlin, Connecticut, and two 1,200 horsepower direct-connected, 100 r.p.m. cross-compound units were installed. The generators were ten-hole machines rated at 850 kilowatts each, operating at about 600 volts. The same type of third rail was installed as between Nantasket Junction and East Weymouth. Storage battery sub-stations were installed to help out on peaks at New Britain, Forestville, and under the platform of the Hartford passenger station. These were later replaced by rotary sub-stations.

The trains were operated normally with two cars 51 feet long, each seating 96 passengers. The forward car was always the motor car, but both cars were equipped with shoes, not only to bridge the gaps in the third rail at switches or highway crossings, but to provide for the possible loss of a shoe.

The next electrification development occurred in 1898, when the New Britain electrification was extended to Bristol, Connecticut, and to Cooks, Plainville and Forestville, a distance of 8.8 miles. This was all on the basis of a third rail distribution. While the steam railroad was double-tracked in this section, one track only was electrified, the other one being retained for steam operation.

At about this time also the Nantasket Beach electrification had been extended from East Weymouth to Brain-



Truck of the Manufacturers Railroad Showing Motors

tree, 4.4 miles of double track. This was also on the basis of standard third rail construction. In 1899 the electrification was extended from Nantasket Junction to Cohasset, a distance of about 3.4 miles.

Operation was continued thus until 1904, when the traffic between Braintree and Cohasset had fallen off so greatly that operation was not profitable, and the third rail in that section was therefore abandoned. The Nantasket Beach Branch, however, is still operated as formerly, except that with purchased power it is practicable to operate the year around. Freight is also now handled electrically on this branch.

The steam road from Stamford to New Canaan, Connecticut, a distance of 8 miles, was also electrified at about this same time. This New Canaan Branch was equipped with an overhead trolley in order that interchange of operation could be made with the local street railway equipment. The track ran parallel to the steam railroad main line at Stamford for about two miles. Octagonal yellow pine poles 30 to 33 feet long, 8 inches at the top and 10 inches at the butt, were used. The trolley wire was 3/0 and 4/0, suspended direct from brackets. There were no trolley frogs, the pole being shifted by hand at turnouts and cross-overs. The bonds were installed under the rail flange as with the other installations.

The power plant was at Stamford and was equipped with two Greene single non-condensing engines direct connected to 300 kilowatt generators. This power plant is now used as a sub-station by the Connecticut Company for its street railway operation at Stamford, the power being supplied from the N. Y., N. H. & H. R. R. traction distribution system at 11,000 volts, three-phase, 25 cycles.

In 1908, after the main line electrification had been extended successfully from New York to Stamford, the New Canaan Branch was reconstructed and catenary installed. The line was insulated for 11,000 volts and standard main line equipment run over it. It is operated thus at present.

The Manufacturers Railroad, organized by the Bigelow Boiler Company and other manufacturers in New Haven, and which is now owned and operated by the New York, New Haven & Hartford Railroad Company in the city of New Haven, had been operated initially by means of "horse power," the horses taking cars from the steam railroad interchange tracks and hauling them along the right-of-way of the Manufacturers Railroad and through the city streets to the individual factories. This railway was two miles long and contained grades as high as 2½ per cent.

In 1896 a 30-ton locomotive was purchased, which was placed in operation on December 11. This locomotive had a drawbar pull of 7,000 pounds and a length over all of 16 feet 6 inches, with a wheel base of 5 feet 6 inches. There were four drivers 44 inches in diameter and two gearless motors mounted on quills around the main axles. The locomotive hauled two loaded cars up a 2 per cent grade at a speed of seven miles an hour. It is of interest to note that this locomotive was exhibited at the World's Fair at Chicago in 1893, and is thus one of the earliest, if not the first, electric locomotive to be built.

Electric Locomotive Used on the Manufacturers Railroad

In 1901 the electrification of the Providence, Warren & Bristol Branch, which was projected in 1898, was completed. That road is double-tracked from Providence, R. I., to Warren, and divides at that point, one single track extending to Bristol, R. I., and another to Fall River, Mass. The power plant was located at Warren, R. I., and contained two 850 kilowatt 625 volt generators, direct connected to two cross-compound Greene engines. Ten 200 horsepower H. R. T. boilers in two batteries furnished the steam. Steam jets were used in connection with burning as fuel, front end cinders obtained from engines of the New York, New Haven & Hartford Railroad. The cost of fuel was thus only the expense of hauling these cinders to the power station. This may be

said to have been the forerunner of the use of pulverized fuel.

Two storage battery stations of 800 ampere-hour capacity, 250 cells each, were installed at East Providence and Brayton, R. I., respectively, to assist on peaks.

Car repair facilities with transfer table and other necessary tools were installed at Warren near the power plant.

The rolling stock at first consisted of 46 cars. Of these 24 were trailers. There were nine combination baggage and passenger coaches and two combination baggage, express and mail cars, all of which were motor cars. These were forty feet long over all and weighed 20,000 pounds. There was also one standard 70-foot coach equipped with motors. The motor cars were equipped with four 80 horsepower motors each.

The power distribution system was overhead. The trolley wire was 4/0 round copper, suspended direct from span wire or bracket construction. The rail bonds consisted of leaf bonds installed as were those of the other electrifications.

The initial operation included 112 trains. Under steam operation between Fall River and Providence the schedule was 48 minutes with 14 stops. With electric operation the local trains making 26 stops accomplished the distance in 45 minutes, and the express trains, making 7 stops, in 33 minutes. On the Bristol Branch the scheduled time under electric operation was 6 minutes with 4 stops, while under steam operation 7 minutes had been required with no stops. The fare between Providence and Fall River was reduced from 50 cents to 20 cents.

In 1905 two steam turbines were installed at Warren and a second modification of the power plant thus made, the first having been a change from a preliminary plant at Warren shortly after initial operation. Alternating current was generated at 13,200 volts and rotary sub-stations installed in place of the storage batteries at East Providence and Brayton. A new steel stack 130 feet high was installed at that time, together with B. & W. water tube boilers. A third change occurred in 1912 by the addition of another turbo-generator of 3,750 kilowatts capacity. The original cars were replaced by larger equipment to take care of the increased traffic.

Plans were pretty well developed at one time to install a third rail section between New Haven and Derby, with a large power plant at New Haven. The electric operation of suburban traffic in the vicinity of Boston was also seriously contemplated at that time. In fact, the loop which now exists at the South station was installed with this in view.

In 1905 the Legislature of Connecticut ordered the installation of some form of protection for the third rail on the Hartford-Bristol electrification. The railroad company contended that it was the duty of the public not to trespass on the right-of-way, and that it could not undertake to protect trespassers from injury on account of the third rail. The State insisted, and in July, 1906, the third rail installation was discontinued by court order.

In 1906 and 1907, however, there was considerable activity in branch line electrification, largely in connection with street or interurban operation. In 1906 the road was electrified between Berlin and Middletown, and between Meriden and Westfield, Middletown and Cromwell, and Tafts and Central Village, all in Connecticut. The construction was all overhead trolley direct suspension, and generally wood pole and bracket construction. In 1907 the tracks from East Hartford (Burnside), Connecticut to Vernon, Rockville and Melrose, were electrified, also with overhead trolley. On the section between Burnside and Vernon a catenary system was installed for high speed operation. On account of falling off in traffic, however, the Rockville-Melrose electric operation was discontinued in 1917 and the construction removed.

It was at about that same time (1906) that the electrification of the suburban territory at New York was installed. The early electrification experience of the railroad was of value in determining the characteristics of the new installation, although both in character and extent of traffic the New York suburban electrification, of course, far exceeded anything which had gone before. As is well known, this electrification, which was installed initially only as far as Stamford, Connecticut, and included only passenger service, was later extended to New Haven and embraced not only local and through passenger service but freight and yard switching as well, and now comprises, perhaps, the most important and comprehensive electrification system in the world.

P. R. R. Electrifies Fort Washington Branch

AN interesting development in railroad electrification, showing the flexibility of the 11,000-volt a.c. system, is the recent electrification of the Fort Washington Branch of the Pennsylvania Railroad System operated electrically since February 27, 1924. This single track branch extends from Allen Lane Station, on the Chestnut Hill Branch, which was electrified in 1918, to White Marsh

Two Car Train Passing Allen Lane Outdoor Substation onto the Main Line of the Chestnut Hill Branch

Station, a distance of 6.2 miles. The country through which it passes is very rolling, resulting in numerous cuts and fills, with a maximum grade of 1.5 per cent over a distance of 2.6 miles; curves of 2 deg., 4 deg., 7 deg., and 9 deg. obtain, the latter being 1,200 ft. long. It was necessary only to install an overhead catenary system without any additional sub-station, the existing sub-station at Allen Lane being adequate to handle the additional load.

It was found that, by electrifying the branch in this manner, the existing service could be handled at less expense than by steam or by any self-propelled car method, considering all fixed charges and operating expenses. The expense of constructing the overhead line was offset by the fact that it was not necessary to provide any additional electric car equipment, the existing equipment being sufficient by proper adjustment of the train schedule. The present schedule provides six trains in each direction daily, two of which run to and from Broad Street Station, Philadelphia, and the remainder terminate

Overhead Construction Across a Fill Where Guys Are Not Feasible

at Allen Lane, at which point connection is made with electric trains of the Chestnut Hill Branch to and from Broad Street Station. The make-up of the trains is from two to five cars.

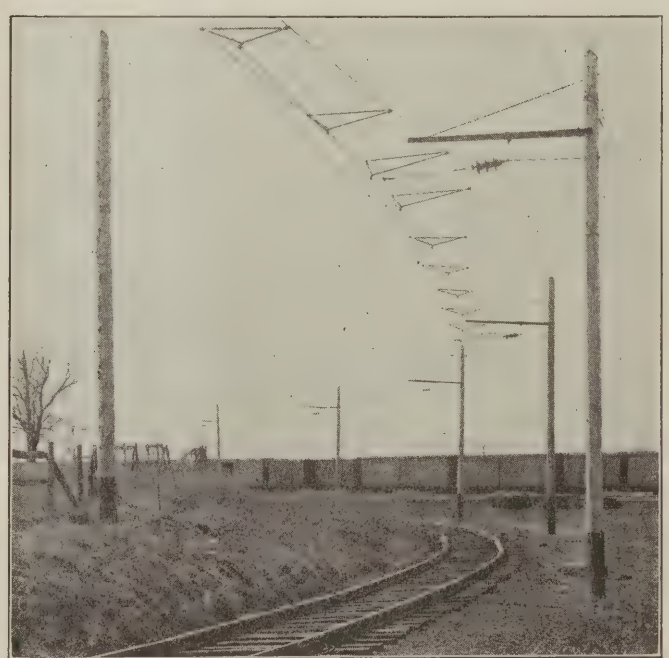
All the work of electrification except pole setting was done by the regular force of linemen used in maintaining the overhead wire structures on the Paoli and Chestnut Hill electrifications and under the supervision of the motive power department of the Philadelphia Terminal division.

The line construction consists of Western cedar poles normally spaced 125 ft., with angle iron brackets supporting the standard catenary wire system made up of ½-in. galvanized steel messenger wire, 2/0 copper auxiliary wire, 3/0 Phono-Electric trolley or contact wire, 3/16 in. by 1 in. galvanized iron hangers, and 4/0 copper return wire attached to each bracket at the pole. The poles are back-guyed with ⅜-in. galvanized steel wire and approximately every half mile the end of the bracket is guyed to adjacent poles on each side. At one location for a distance of about 1,300 feet, a high fill with steep slope on each side necessitated span construction; here a pole was set on each side tied together at the top by double angle irons which support the insulator; these bents were spaced 250 feet.

Around the 9 deg. curve, poles are spaced about 100 feet and special arrangement of catenary construction was necessary to prevent excessive vertical rise of wires due to pantograph pressure. This was accomplished in a unique manner by installing a second messenger wire supported from the same insulators to which the first messenger is attached, and a triangular hanger arrangement between the two messengers and trolley wire.

Owing to the relatively close normal spacing of poles, special bracing to prevent misalignment of trolley wire under wind pressure is not necessary. However, such bracing is provided at each span where the special bent construction is used at spacings of 250 ft. This consists of a triangular angle iron brace having one of the sides supported by a rigid post type insulator and the opposite apex attached to the auxiliary wire.

As with the Paoli and Chestnut Hill electrifications of the Pennsylvania Railroad, the trolley wire carries 11,000-volt, 25-cycle, single-phase power for operating the multiple-unit electric cars. Each car is equipped with two Westinghouse No. 412-A single-phase series repulsion motors, each having an hourly rating of 225 horse power. Power is collected by a pantograph and conducted to a main transformer on each car and fed to the motors at a maximum of 430 volts across each motor;



Nine Degree Curve Construction Using Single String of Insulators and Double Messenger to Insure Proper Alignment of Contact Wire Under Pressure of Pantograph Where Height of Suspension Is Limited

speed control is obtained by selected taps on the transformer.

This branch extends through a residential district which promises well for steady development by reason of the improved transportation facilities.

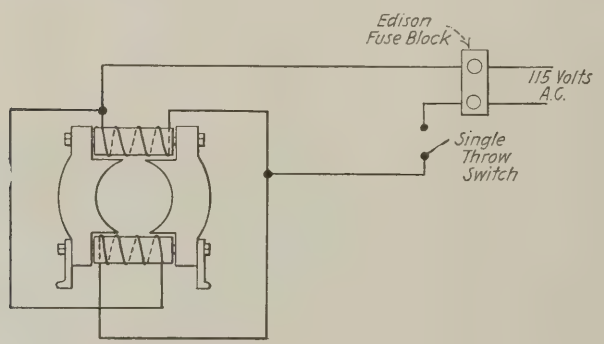
Rapid increase in the use of electricity for domestic purposes has taken place in Glasgow since 1916. Figures compiled by the Electricity Department of the Glasgow Corporation indicate that, although new customers are being constantly added, the rapid increase in the use of electricity has been due principally to increased use per consumer rather than through additional users.

Growler For Testing Headlight Generator Armatures

By James C. Moore
Chicago, Rock Island & Pacific Railway Company, Eldon, Mo.

For testing armatures at the Chicago, Rock Island & Pacific roundhouse at Eldon, Mo., a growler has been constructed of the generator end of a Pyle-National turbo-generator by changing the winding on the field coils. Each of the field coils is wound with 330 turns of No. 13 Cotenamel wire and connected in parallel to the 115-volt alternating current shop supply circuit through a single throw single pole switch and a double pole Edison type fuse block. The fuse block is supplied with two 30-ampere plug fuses.

The armature to be tested is placed in the magnetic field and the circuit is closed. A small three-cornered file



Circuit Used for Growler Made by Rewinding Headlight Generator Field

drawn loosely down between adjacent segments of the commutator will disclose shorted or open coils. A small flashlight lamp is used to determine if a coil is weaker than others in the armature.

In using the file, it is held by one end and drawn downward very lightly. It is done in this fashion so that the wear on the commutator will be a minimum. The reason for using a three-cornered file is that it produces a large amount of sparking with a relatively small current in the armature segment. The flashlight lamp is used to verify conditions in a coil that gives a doubtful spark. A partially short circuited coil will give a dimmer light than a good one. An open coil will give no light and neither will a shorted one. An open coil will not heat and a shorted one will.

A winding in which there is a partial short is considered as no good as it will usually take as much time to find the defective spot as it will to replace the coil. This, of course, does not hold good if the defect is in plain sight and because of the trouble apparent. The method described above is used in preference to instruments.

The Train Control Nightmare

I was a happy engineer; I had but little worries here, to thwart my tranquil soul: until my life was all upset, by dope which I am forced to get, upon this train control. . . . I'm reminded of the cavern scene in Macbeth where those witches mean: bring in their grewsome stuff, and dump it in the boiling pot, which agitation now keeps hot: Ye Gods! this play is rough.

I've studied circuits for the track, that alternate both up and back, with various volts and amps: I've pondered on induction types, and others where a contact wipes, on long and rusty ramps. . . . This word "continuous" gets my goat, when a salient point I would denote—in the language of the land. If I use "control" I'm off my base: I put "indication" in its place, and hope they understand. . . . Shall I the cheapest thing now try; which with the "order" will get by, or shall I blow our jack, on something which will really be, an asset to capacity, along our busy track. . . .? These patents lap and interlock; they will breed troubles by the flock (the kind which won't behave). When future litigation starts, we'll haul our goods on sleds and carts, while legal talents rave. . . . I've studied logarithmic charts, and delved into most all the arts, which addle up the brains: if this Commission does stand pat, I don't know wherethell I'm at, when it comes to stopping trains.

I'm running 'round in circles small, and getting to no place at all, except to fret and stew: in the daylight and the dark, I face a large-sized question mark, for I don't know what to do. If I should crave a brief respite, so I can figure this thing right, to know just what to do: they'd say, go dry your useless tears, this thing's been comin' fifteen years, so now it's up to you. One little thing I'd like to know, before we face next Winter's snow—I'm looking for advice—if you birds can recollect, please tell me how you did select, some particular device. . . .

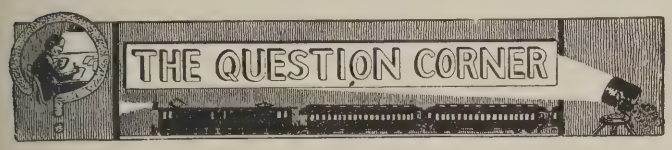
Soon requisitions will be filed, followed by a scramble wild, to get the stuff in place. If I can't fix up this delay, and save the "hundred bucks per day," we're fined and in disgrace. . . . With all the many little things, having horns and fins and stings, that's going in the pot, these witches chant with ghoulish glee a song that puts the jinx on me—and some sunrise I'll be *shot*.

A Habit Hard to Overcome

A schoolmaster offered a prize to the boy who would write the best composition in five minutes on "How to Overcome a Habit."

At the expiration of five minutes the compositions were read. The prize went to a lad of twelve years. The following is his essay:

"Well, sir, habit is hard to overcome. If you take off the first letter, it does not change 'a bit.' If you take off another you will still have a 'bit' left. If you take off still another the whole of 'it' remains. If you take off another it is wholly used up; all of which goes to show that if you want to get rid of habit, you must throw it off altogether."



Answers to Questions

1. *Why is it that an electro-magnet of the horseshoe type, one end of which is rounded, has the greatest tractive power on the rounded end?*

2. *I would like to use a voltmeter to measure insulation resistance of conductors. Is this practical?*

Strength of Horseshoe Magnet

1. The pull in pounds or strength of any electro-magnet is, of course, dependent upon the strength of the current circulating through its windings. Assuming a correctly designed magnet in which the magnetic leakage is small, the same number of lines of force pass out of one end of the horseshoe as enter the other. If both ends of the

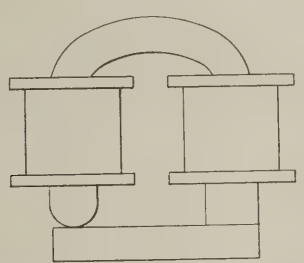


Fig. 1

magnet are exactly alike the amount of pulling force or attraction is the same at both. However, if one of the ends is rounded as indicated in Fig. 1, it will be found that the rounded end has the greater tractive power. The reason for this is not immediately apparent, but a close inspection of the formula for magnetic attraction will show mathematically, at least, why it is so. The formula for pull in pounds is:

$$P = \frac{B^2 A}{72{,}134{,}000}$$

where P equals the pull in pounds, B the magnetic density at the pole faces in lines per square inch, and A the polar area in square inches. Since practically the entire flux passes through both ends of the magnet it is obvious that the flux density at the rounded end will be very much greater than at the flat end. Furthermore, when this value is squared as is indicated by the formula, the result is a very large number. In working out the formula it will be found that the result, P, will be very much greater for the rounded end than for the flat end.

Measuring Insulation Resistance with Voltmeter

2. It is entirely practical to measure the insulation resistance of wires by means of a voltmeter, although a much quicker way is by the use of a special instrument known as a "megger" which gives the resistance in ohms or megohms without any computation. However, such

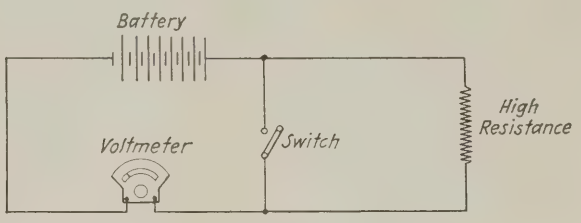


Fig. 2

instruments are expensive and the voltmeter method is quite satisfactory.

The voltmeter used should be of known resistance and this resistance should be quite high. The connections should be made as shown in Fig. 2. A battery is shown in the sketch as a source of e.m.f. and this should be as high as possible within the range of the voltmeter. A constant potential circuit supplied from a generator may be used, but unless the voltage is very steady the results will not be as accurate as with the battery. Two readings on the voltmeter are taken. The first d is taken with the

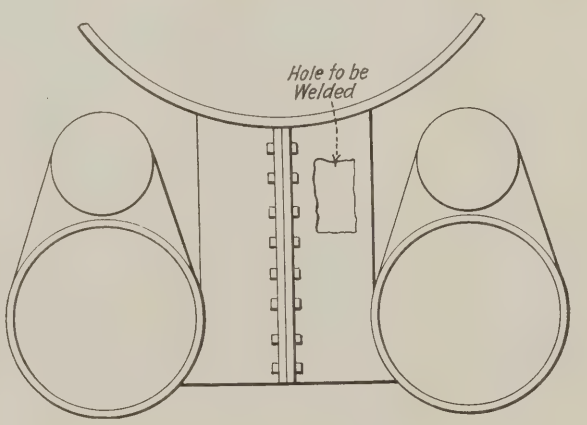


Fig. 3

switch closed. The second deflection is observed after the switch has been opened and the resistance is in series with the voltmeter. This is known as d_2. The next and final step is to substitute these values in the formula:

$$R = r\left(\frac{d}{d_1} - 1\right)$$

Where R is the insulation resistance required and r is the known resistance of the voltmeter. Working out this formula the value of R is readily obtained.

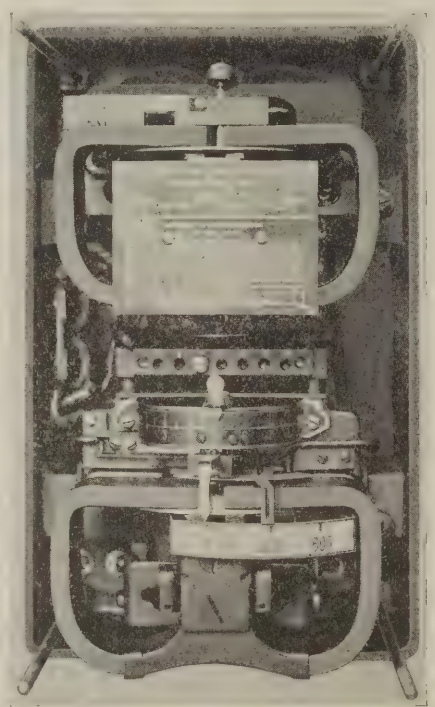
Questions for May

Is it possible and practical to close a hole in a broken casting as indicated in Fig. 3, using the electric arc welding process and a piece of tank steel?—J. W. M.

NEW DEVICES

Relay With Self-Contained Ammeter

A line of overcurrent and directional relays equipped with a current indicating element is a product of recent work by the Westinghouse Electric and Manufacturing Company in the field of protective devices for electrical circuits. These relays known as COA and CRA, differ from the standard Westinghouse CO and CR overcurrent and directional relays in that they have self-contained ammeters which give a continuous indication of the current flowing in the circuit to which the relay is connected. They are designed for use where the relays are mounted on the front of a switchboard and where there is insufficient room to provide separate ammeters. Particularly are they desirable where it is considered advisable to have continuous supervision over the current circuit of the relay.



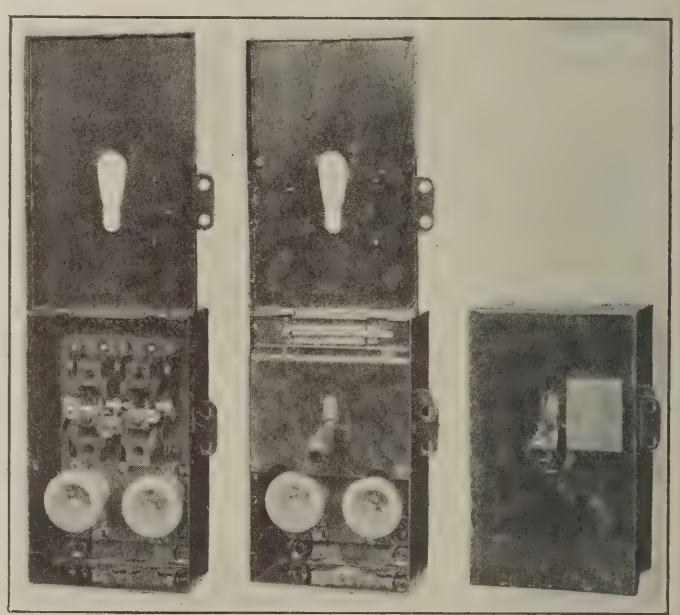
Westinghouse Type CRA Directional Relay

In addition to operating as protective relays, these relays indicate the current flowing through the relay circuit, which not only shows the current in the feeder, but also proves to the operator that the relay is receiving current through its circuit and is therefore in condition to operate if a short circuit should occur.

The indicating element of this new relay consists of a thin copper disc mounted on a separate shaft and having its own jewel bearing and control spring. It is actuated, however, by the same flux which operates the main disc to close the contacts of the relay. This prevents the indicating element from operating when there is any trouble either inside or outside the relay that would prevent the main electro-magnet from being energized.

Starting Switch for Small A. C. Motors

A new single-throw starting switch, the CR-1038-A1, has been put on the market by the General Electric Company for use with small alternating-current motors. This switch is of the three-pole type, designed for quick "make and break," and is operated by an up-and-down movement of the handle. The unit is compact and of substantial construction to permit of wall or pedestal mounting.



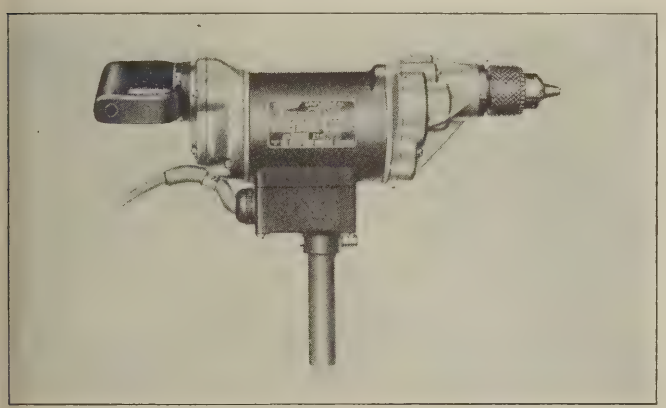
Three Views of the CR-1038-A1 Starting Switch. 1, Cabinet Open and Safety Cover Removed; 2, Cabinet Open and Operating Handle and Safety Cover in Place; 3, Cabinet Closed

Overload protection is provided by means of two thermal cutouts, one connected in each of two legs of the motor circuit, in order to protect all phases of the motor against unbalanced and single phase overloads, as well as overloads distributed over all phases. These thermal cut-

outs have an inverse-time characteristic and sufficient thermal capacity to permit the motor to operate at all overloads of short duration that are not objectionable from the standpoint of overheating the motor. A new feature in the design of these cutouts is the elimination of the old screw base, two screws being used to fasten the cutout in place, the screws being readily loosened to remove the device if necessary. The fusible links may be removed without removing the cutout.

Side Handle Portable Drill

A high-speed portable drill suitable for wood and metal drilling has recently been placed on the market by the Hisey-Wolf Machine Company, Cincinnati, Ohio. The machine is of sturdy construction, small and compact, and is as light in weight as good practice will permit. All parts are easily accessible, which was made an important feature in its design in order to reduce maintenance costs. All bearing surfaces are equipped with ball bearings. The



A Portable Electric Drill for Wood and Metal

lubrication for all the bearings, gears and other moving parts in the gear end of the machine is supplied from the gear transmission case, while the ball bearing on the top head is packed with grease. All gears are machined and are heat treated in order to secure toughness and long life. The illustration shows the type designed for drilling hard metal, where a slow speed is often preferred. It can be operated on either 115 or 230 volts and runs at a no load speed of 1,250 r.p.m. At normal load, its speed is 760 r.p.m. and it has a capacity in steel of 5/16 in. It has an overall length of 14 in. and weighs 12 lb. in working order.

Track Inspection Headlight

A track inspection light, designed especially for use in connection with night inspection from moving trains, has been recently built by the Sunbeam Electric Company of Evansville, Ind. Two lights are used on the inspection car which is connected to the end of the train. The lights are mounted underneath the rear platform, one light above each rail thus clearly illuminating the track. The lights are furnished in pairs and are bolted to the frame of the car by the flange shown at top headlight. The construction is such that the lamp and focusing device are readily accessible. Interchangeable doors are provided at the front and back of the headlight, the front door giving access to the reflector and lamp and the rear door giving access to the focusing device. The mirror glass reflector, 12 in. in diameter by 4½ in. deep is used, together with a standard 100 or 250-watt loco-

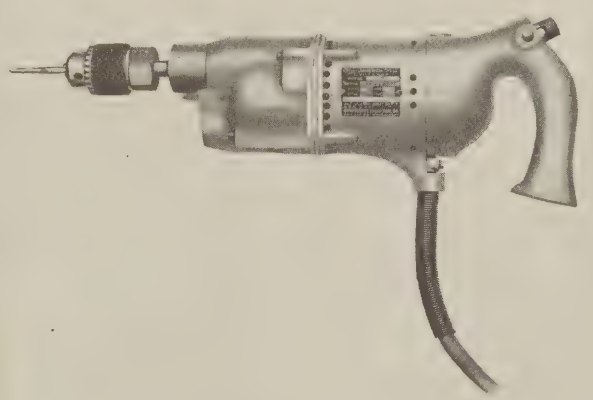
Two Units of This Type Are Mounted Under Rear Platform of Inspection Car

motive headlight lamp of 32 volts. The current used is taken from the regular car-lighting circuit.

Reversible Electric Tapping Machine

A portable tool for tapping drilled holes, similar in design and appearance to a portable electric drill, has been designed by the Independent Pneumatic Tool Company, Chicago, Ill. It is known as the Thor Reversible Electric Tapping Machine and the size UKR, now being announced, is suitable for tapping holes up to 3/16 in. in diameter and for retapping holes up to 5/16 in.

The machine has the same motor as the standard Thor



Size UKR Thor Tapping Machine

Portable Electric Drill, but the speed of the spindle has been reduced to 550 r.p.m. through worm gears which are enclosed in the gear case. The reversing device is mechanical. A slight pressure toward the work will engage the clutch and cause the spindle to rotate toward the right.

A universal motor is used so that the machine can be operated on either alternating or direct current circuits of 110 or 220 volts. The weight of the machine is 6¾ lb.

General News Section

The Association of Railway Electrical Engineers will hold its semi-annual meeting on Thursday, June 12, at the Hotel Dennis, Atlantic City, N. J.

The Westinghouse Electric & Manufacturing Company has moved its New York offices to the new Westinghouse building, 150 Broadway.

The boiler shop and three other buildings of the Missouri Pacific shops at Ft. Scott, Kans., were destroyed by fire on April 16; estimated loss $30,000.

A fire at Buffalo, N. Y., on the night of April 18 destroyed a four-story warehouse of the New York Central, at Washington and Green streets; estimated loss $50,000.

The Central New England has filed a petition with the Interstate Commerce Commission for an annulment, as to the C. N. E., of the order of January 14, requiring an installation of automatic train control.

The Oregon-Washington Railroad & Navigation Company is to install the Union automatic train control on 84 miles of line between Portland, Oregon and The Dalles, single track. A total of 33 locomotives will be equipped.

On May 1, 1924 the National Carbon Company, Inc., moved its Chicago Brush Finishing Plant from 560 West Congress Street to new and larger quarters, affording much better facilities, located at 551 West Monroe street. This new location will enable them to double their output and extend service in the Chicago District.

The Erie is endeavoring to determine who of its commuters into New York has been traveling on its lines the longest, and to this end will award a prize to the record-holder. One entrant with fifty-five years to his credit died on April 23, leaving another with a record of fifty-three years, thus far, at the top of the list.

The Ohio Brass Company recently purchased approximately five acres of land, and buildings, just across the Pennsylvania Railroad tracks from its present Mansfield, O., plant. The tract is triangular in shape and is bounded by three trunk-line railroads—the Pennsylvania, the Erie and the Baltimore & Ohio. The purchase was made from the Aultman-Taylor Machinery Company.

The Packard Electric Company, Warren, Ohio, celebrated the opening of its new transformer plant on May 3 when the Akron Section of the American Institute of Electrical Engineers held a meeting at the plant. The subject for discussion was "Instrument Transformers" and an illustrated lecture on this subject was delivered by Edward S. Foster, development engineer for the Packard Company.

Strom Ball Bearing Manufacturing Company, Chicago, Ill., is the new name which has been adopted by the manufacturer of Strom bearings. The old name of the company was the U. S. Bearing Manufacturing Company. The change was made so that the company and the product would have the same name. No changes have been made in the personnel of the company and the manufacturing principles which have governed this concern's business will remain the same.

The Kuhlman Electric Company, Bay City, Mich., manufacturers of power, power distribution and street lighting transformers, have opened a sales office at 300 Madison avenue, in charge of D. F. Potter, Jr. Mr. Potter is a graduate electrical engineer, Cornell, 1916. After completing the General Electric test course he entered the employ of the Robertson-Cataract Electric Co. of Buffalo, as sales manager. A year ago Mr. Potter became sales engineer for the Kuhlman Electric Company in Buffalo.

The Union Pacific has selected the Union two-speed super-imposed continuous automatic train control system for installation on 102 miles of its line, double track, between Sydney, Neb., and Cheyenne, Wyo. One hundred locomotives will be equipped with train control apparatus. The present block signal system consists of two-arm, lower quadrant semaphores controlled from d. c. track circuits. The railroad company will install the apparatus, the materials being supplied by the Union Switch & Signal Company.

The Chicago Fuse Manufacturing Company has announced a reorganization which includes the purchase by its president, W. W. Merrill, of the remaining block of stock held by A. D. Dana of New York City, until recently chairman of the board, who has been inactive in the management of the company's affairs for a number of years. The capital stock has been changed from 7,500 shares of $100.00 par value to 60,000 shares of no par value. Thirty thousand shares were offered to the public. A considerable share of these 30,000 shares were purchased by Mr. Merrill and his associates, including employees of the company throughout the general office, sales department and factory. The active management of the company will remain the same as heretofore. Mr. Merrill and his associates own the controlling stock of the corporation and there will be no change in its policies or method.

Electrical Industry Co-operates with Railroads

An unusual but altogether proper point of view has been adopted by the Western Electric Company, of Chicago, who recognizes that railroads are of vital importance in the industrial world today. In order to instil the correct impression into the public mind, the Western Electric Company has devoted extensive advertising space to the exposition of the truth about the railroads, and there is no doubt but that the publicity which the company has given in portraying the actual facts has been no small factor in bringing the public mind to a better appreciation

of the tremendous difficulties which confront railroad operation. The campaign has been carried out by means of the distribution of pamphlets, radio broadcasting from high power stations, and the devotion of large advertising space in national magazines. An excellent example of this publicity is the speech presented by P. L. Thomson, publicity manager for the Western Electric Company.

Electrical Engineers at Philadelphia Hear Paper on Electrification

A meeting of the Philadelphia Section of the American Institute of Electrical Engineers was held at the Bellevue-Stratford Hotel on April 14. J. V. B. Duer, electrical engineer of the motive power department of the Pennsylvania Railroad, presented a paper entitled, "Railroad Electrification, Its Present Developments and Future."

A very large part of Mr. Duer's talk was historical; it went back to the earliest days of electric operation, his first reference being to the installation of a street car line in Richmond, Va., in 1888. In continuing the paper, Mr. Duer mentioned practically all of the electrification projects in the United States which have been undertaken during the last 25 years.

The reasons for the adoption of electric motive power in the various instances were pointed out and the well-known advantages and disadvantages were rehearsed. Mr. Duer's remarks were illustrated by a large number of lantern slides.

Personal Thrift on the P. R. R.

The Pennsylvania Railroad reports that 3,901 employees have bought shares of the company's stock through the facilities afforded by the Employees' Provident & Loan Association. The stock owned by these employees now amounts to 19,666 shares ($50 a share), which is in addition to the holdings acquired by employees through other channels. The most popular block of stock is two shares, 1,433 employees having become shareholders to that extent. Purchasers of one share number 992; five shares, 549 employees, and ten shares, 350. Of the total of 19,666 shares, 6,686 were bought outright. Over 500 members are purchasing increased pensions through the Association. Savings accounts have been opened by 13,978 members, and their total deposits now exceed $4,000,000. Seventy-nine members are purchasing homes through loans granted by the Association, and these loans now total $275,435.

Moffat Tunnel Commission Granted Right-of-Way Over Public Lands

Tentative approval has been given by Secretary of the Interior Work to the granting of a right-of-way over public lands for the construction of a tunnel through the continental divide between Grand and Gilpin counties, Colorado. The application was filed by the Moffat Tunnel Commission, which plans to build a tunnel approximately 9,200 feet above the sea level, the eastern portal to be located at the most practical site on the eastern slope of the continental divide and near the headwaters of the South Boulder creek, with the western portal to be located at the most practical point on the western slope near the headwaters of the Frazier river. The tunnel and its approaches will be constructed of such size so that it may be used for standard gage railroads, for the transmission of power, for telephone and telegraph lines, for the transportation of water, automobiles, and other vehicles.

Reading's Camden Terminal to Be Opened May 14

The Reading will open its new passenger terminal at Camden, N. J., on May 14 and the opening will be celebrated with appropriate ceremony. The company will send out 10,000 invitations in this connection, and will operate special trains from various Jersey coast points to Camden to carry its guests, who will include city and state officers, presidents of chambers of commerce and other prominent citizens.

Personals

Leo John, formerly electrician at the St. Paul, Minn., coach yard, on the Minneapolis, St. Paul & Sault Ste. Marie R. R., was recently appointed foreman electrician at the same place.

S. D. Dimond, chief electrician, on the Minneapolis, St. Paul & Sault Ste. Marie R. R., has recently moved his headquarters from the St. Paul coach yard to the Shoreham Shops at Minneapolis, Minn.

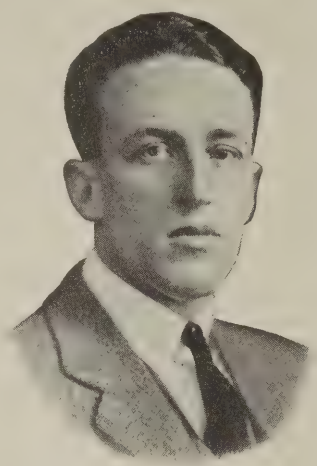
Albert C. Coover, formerly carlighting electrician in the St. Paul, Minn., coach yard of the Minneapolis, St. Paul & Sault Ste. Marie R. R., was recently appointed foreman electrician at the Shoreham Shops of the same road at Minneapolis, Minn., where he will be in charge of the battery house and carlighting work at that point.

Charles A. Coffin, former president of the General Electric Company, Schenectady, N. Y., was awarded a certificate of honorary membership in the Franklin Institute on April 16 at Philadelphia, Pa. This honor was conferred in recognition of Mr. Coffin's many achievements and contributions to the electrical industry.

E. A. Lundy, formerly business manager of the *Railway Electrical Engineer* and Railway Signaling, has resigned to organize the E. A. Lundy Company, with headquarters in the Union Trust Building, Pittsburgh, Pa., to take over the sales and service of the following companies in the railway field: The Line Material Company, South Milwaukee, Wis., manufacturers of line materials of all kinds for both low and high tension work; the Howell Electric Motors Company, Howell, Mich., manufacturers of polyphase induction motors; the Matthews Engineering Company, Sandusky, O., manufacturers of automatic light and power plants for signal station yard lighting and emergency work; the Fan-

E. A. Lundy

steel Products Company, North Chicago, Ill., producers of electrolytic rectifiers for signal and telegraph service, and the Verona Tool Works, Verona, Pa., manufacturers of the Verona rail-spring and signal bond. Associated with Mr. Lundy in this work will be Preston Parish, formerly of the Line Material Company, and Earl M. Allen, formerly of the Matthews Engineer Company.



Preston Parish

Mr. Lundy is a graduate of Pratt Institute, Brooklyn, N. Y., electrical engineering department. His first railroad experience was with the Atlantic Coast Line in the electrical department. After a year's service a transfer was secured to the signal department, where he was engaged from March, 1913, to September, 1916, in various capacities on construction and maintenance work. From September, 1916, to June, 1918, he was connected with the signal department of the Long Island Railroad. Upon leaving the Long Island, Mr. Lundy entered the services of the Union Switch & Signal Company and remained there until January, 1920, at which time he resigned to accept a position with the *Simmons-Boardman Publishing Company.* With this company he served in various capacities, which included the business managership of the *Railway Electrical Engineer* and Railway Signaling which position he held at the time of his resignation to enter the railway supply field. Mr. Lundy is the junior vice-president of the Railway Electrical Supply Manufacturers' Association and chairman of the Committee on Economics of the Electrical Appliances of the Association of Railway Electrical Engineers.

E. M. Allen

Preston Parish, formerly with the Line Material Company, South Milwaukee, Wis., has resigned to enter the services of the E. A. Lundy Company as manager of the line materials division. His technical training has included structural and mechanical engineering. Previous to Mr. Parish's connection with the Line Material Company he spent six years in the sales organizations of the U. S. Rubber Company, Hood Rubber Company, and the Miller Rubber Company in connection with their mechanical goods department. During that time he also was active in railway work.

Earl M. Allen, formerly with the Matthews Engineering Company, Sandusky, Ohio, has resigned to enter the services of the E. A. Lundy Company as signal engineer. Mr. Allen is a graduate of the University of Minnesota in electrical engineering. In 1913 he entered the services of the Great Northern on construction and maintenance of signals. In 1914 he accepted a position with the General Railway Signal Company on engineering and construction work. Mr. Allen left, in 1917, to go with the Interborough Rapid Transit in connection with the signal construction on the subway, and returned to the General Railway Signal Company in 1919, and in 1920 went over to the Toledo & Ohio Central on signal construction work. In 1922 he accepted a position with the Matthews Engineering Company, which position he held until his recent appointment.

Dan Herbert Green, sales engineer of the National Carbon Company, has been appointed assistant manager of the railway sales division with headquarters at 550 West Congress street, Chicago, effective March 15. Mr. Green was born at Braidwood, Ill., June 13, 1894, and was graduated from the James Millikin University, Decatur, Ill., in the electrical engineering department in 1913. He began railway work in the signal department of the Wabash. The first three years were spent in the construction and maintenance organization. In September, 1916, he was appointed office engineer of the signal department. In July, 1918, he was promoted to signal foreman and in April, 1919, to signal valuation statistician. He was appointed service engineer of the National Carbon Company, Inc., in Novembeer, 1919, and in September, 1921, was promoted to sales engineer, which position he held until the time of his recent promotion to assistant manager of the railway sales division.

Dan Herbert Green

E. W. Allen, formerly engineer and assistant manager of the central district of the General Electric Company, with headquarters at Chicago, has been appointed manager of the engineering department of that company and A. F. Riggs has been appointed district engineer to succeed Mr. Allen. E. W. Allen was born in Buchanan, Va., on November 8, 1880, and was graduated from the Virginia Polytechnic Institute in 1900 with a B. S. degree in electrical engineering. He first entered the employ of the General Electric Company in January, 1901, in the test department at Schenectady, and in December of the following year he was assigned to the lighting engineering department, where he remained until September 30, 1911, when he was appointed engineer of the Chicago district. On September 1, 1913, he was appointed assistant district manager in addition to his duties as district engineer. Early in 1917 he entered the military service and served two years. He returned to the company in April, 1919.

Railway Electrical Engineer

Volume 15 JUNE, 1924 No. 6

Purchased or Generated Power?

With the advent of large central stations and inter-connected power systems, there is a natural and logical tendency on the part of the railroads to buy more power and generate less. On the other hand the railroads are every year using larger and larger blocks of electric power. An attractive rate will probably warrant the purchase of some power in almost any locality, but unfortunately low rates are not everywhere obtainable, and in places where the railroad has need for much power and good use for exhaust steam, it frequently happens that the best thing to do is to build a new power plant or increase and improve the facilities in the existing one.

Unfortunately, few railroads have a good power plant organization. A stationary power plant organization is fundamentally different from one designed to operate locomotives and when the question of buying or generating power is brought up, it is natural for the management to err in favor of purchased power. Subsequent issues of the *Railway Electrical Engineer* will contain articles on suggested forms of power contracts, descriptions of modern railroad power plants which generate all the power used at a certain point and others which purchase electric power and also generate steam for power and heating. These articles will not solve the problem for the reader, but it is hoped they will shed some light on the subject and will encourage readers to send in expressions of their opinion.

Lamps and Voltage

No matter how well or how carefully a lighting system may be laid out, if it is not properly maintained, if the lamps used do not fit the reflectors or if they do not have the proper voltage rating, the effectiveness of the lighting system will be spoiled and in all probability much electric power will be wasted. Too often when a lamp burns out a requisition is issued for "One lamp." This requisition is taken to the storekeeper and when he asks what kind of a lamp is wanted, the answer will be "Give me the biggest one you've got."

The result of this will be that the lamp will be too large for the reflector in which it is used. It will give lots of light but it will be a spotty, poorly distributed light and in all probability the lamp will project from the bottom of the reflector so that the unprotected filament will be in the line of vision, making an objectionable glare. Naturally, too, the cost of electric power will be increased.

Similarly, if the voltage rating of the lamp is incorrect, either not enough light is produced for the power consumed or the life of the lamp is reduced. It is practically impossible on a railroad to standardize voltage, as power is purchased from a variety of power companies at widely distributed points and these companies can seldom afford to adjust their voltages to comply with the wishes of the railroad consumer. Accordingly, voltages along the line will probably vary from 110 to 120, and perhaps more than that. Some railroads attempt a compromise and standardize on a 115-volt lamp. This may be the most practical solution of a difficult problem, but certainly it is not the best.

Much time and effort can be spent in evolving a system which will cause the lamp of the proper size and voltage to be used in every reflector on the railroad. It is not an easy thing to accomplish, but almost any Class 1 railroad would save thousands of dollars annually if it had some effective means for accomplishing this most desirable end.

Lighting of Classification Yards

It will be remembered by those who were in attendance at the last annual convention of the Association of Railway Electrical Engineers that the subject of yard lighting was one which came in for a large amount of discussion. At that time there appeared to be considerable divergence of opinion as to what was the best method to use in order to accomplish the most desirable results. Those who are concerned with this problem will be interested in the article entitled, "Railroad Yard Lighting," on page 185 of this issue. The author has pointed out the advantages and disadvantages of the various types of lighting that are being used at present in different yards. While the matter of securing adequate lighting for classification yards is of prime importance today, there is no question but that it is something which will be of greater importance in the future. Terminal facilities are constantly being enlarged in order to handle the ever increasing traffic of the country and the necessity for the very best lighting at congested points is being more and more appreciated.

Although there are many advantages of good lighting, the expeditious handling of cars is probably the one which will be considered of greatest importance in future developments.

As the necessity for duplicating daytime conditions

becomes more and more apparent, the cost of lighting facilities will become of less and less importance, until lighting conditions will be developed which will greatly surpass even those installations which we now look upon as examples of good lighting.

The Convention Reports

Nine committee reports on live, practical problems will be presented at the semi-annual meeting of the A. R. E. E. on June 12 in Atlantic City. These reports will be found on page 175 of this issue of the *Railway Electrical Engineer*. The total number of committees is fourteen but only nine written progress reports arrived in time to be published. It is believed, however, that brief oral reports of progress will be presented on the convention floor.

In view of the large number of subjects to be handled and the comparatively short time that is available in which to do the work it is most desirable that the meeting begin as scheduled at 9:30 a. m. (daylight saving time). The convention will be called to order promptly at this hour in order that the advantage of every available moment may he had.

There is a strong tendency for the discussion to drift into irrelevant subjects and much valuable time may be wasted if this particular point is not watched. There is abundance of material in the reports for discussion and it is only by sticking closely to the subject matter in hand that the committees will be benefited by the support of the members. This matter of adhering closely to the subject under discussion is often treated too lightly but it is actually one of the most important factors in a successful convention and cannot be too strongly emphasized.

Keeping Peace in the Family

The way in which passenger coaches not used in suburban service are operated necessitates that car lighting maintainers at different points on the road must work on the same equipment. It may also happen that the car is maintained by men on more than one road. These men are not acquainted and when a failure occurs the "buck" is often passed back and forth by generous and willing hands. Tom Jones will say: "Now if John Doe would only do so and so, this thing wouldn't have happened." Now it may happen that John has not the facilities for doing the work suggested by Tom, and Tom should have done the work himself before the car left his yards.

There is an old French proverb which when translated reads, "To understand all is to forgive all." With this thought in mind, the electrical engineer of a western road has suggested that the car lighting men who may at times work on the same equipment meet periodically. These meetings would be held first in the repair shop at one location and then at another, until at least the foreman in each shop is familiar with every other shop and acquainted with the men. Having a knowledge of the facilities at each location will permit each man to direct his work intelligently and having become acquainted with the other men personally, he will have found out that the other fellow is not so hopelessly incompetent as he had supposed. The natural result will be that a lot of grief may be eliminated, failures will be minimized and the work will be made more pleasant and agreeable to everyone concerned.

Letter to the Editor

Should Railroads Purchase Power

To the Editor:

I have read with much interest the editorial on page 134 of the May, 1924, issue of the *Railway Electrical Engineer*, entitled "Should the Railroads Purchase Power?"

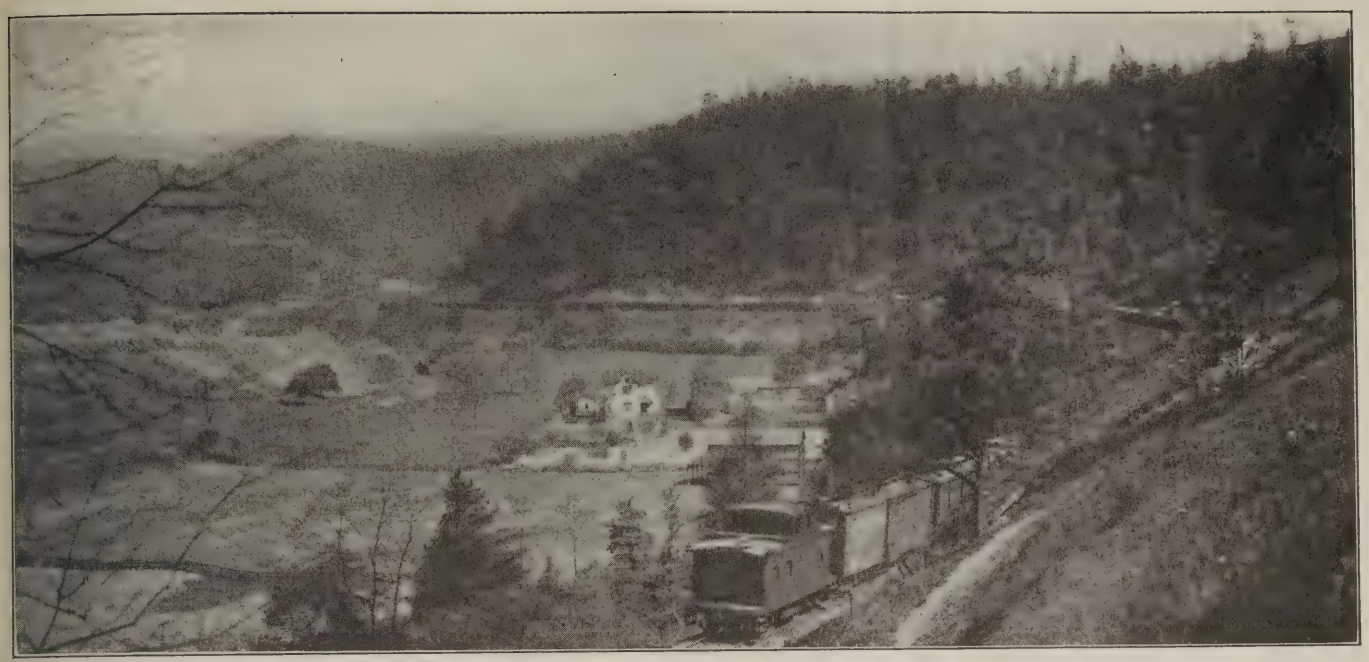
This article states, "Of course, in the ultimate analysis, the matter resolves itself into the fundamental question of economy." With that statement I heartily agree. Also I take no particular exception to the balance of the article as applied to a case where large quantities of electric power are required, such as would be the case where heavy electric traction was being considered, either through freight or multiple unit service. However, the great majority of railroad plants do not require electric power in what would be considered large quantities and at the same time these railroad plants do require a considerable amount of steam for power purposes for which electric power is not suitable, such as blowing up engines, heating water for locomotive washouts and fill-ups, and for heating shops and buildings. Where steam for such purposes is necessary, it is not fair to make a comparison of the cost of electric power at the rate at which it can be purchased with the pro rata cost of generating the same amount of power, as in many cases it will be found that the actual expense for generating the electric power is the cost of the additional coal, water and lubricants consumed plus the fixed charges, maintenance and depreciation of the electric generating equipment.

The ultimate comparison then should be a comparison of the total cost to the railroad, according to the various schemes of operation which were possible, and which will produce for the railroad's use, a sufficient quantity of the various kinds of power required. In other words, the cost of operating the particular plant to generate all the necessary amounts of power, plus the expense of maintaining the plant and the fixed charges on the plant, should be compared with the cost of operating the plant to produce all power which is not purchased electrically (and this may mean changing steam driven equipment to electric driven on one hand or purchase of only a part of the electric power required and the generating of the balance on the other) plus the expense of maintaining the plant and the fixed charges on the plant and plus the cost of the electric power purchased.

In making analyses of average size railroad shop plants my experience has been that, where steam, either live or exhaust, is required the year around, the total cost to the railroad where electric power is purchased is generally, but not always, greater than when that same power is generated.

My experience has also been that with the railroad purchasing the electric power, the number of failures of power greatly exceed the number of failures which occur when power is generated in the railroad plant.

J. R. Sloan,
Chief Electrician, Penna. R.R.



A 60-Car Freight Train Near Rock Station

The Virginian Railway Electrification

An Outline of the Conditions Which Caused the Management to Adopt Electric Traction

By Homer K. Smith
General Engineer, Westinghouse Electric & Manufacturing Company

THE announcement of the undertaking by the Virginian Railway Company early in 1923 to electrify 134 route miles of its main line, extending from Mullens. West Virginia, to Roanoke, Virginia, comprised one of the most important major undertakings by our railroads during last year. The progressive attitude of the Virginian Railway in matters of high capacity equipment, large locomotives and heavy construction, and their well-known charcteristic—mass transportation—made this announcement of the Virginian Railway a particularly outstanding one.

Operating Conditions

The Virginian Railway is primarily a coal handling road. The map, Fig. 1, shows that the main line extends from Deepwater, West Virginia—where connection is made with the Chesapeake & Ohio R. R. to Norfolk, Virginia, a route distance of 441 miles. The line is single track except from Mullens to Clarks Gap, which section includes the heaviest grade against load movement and is double tracked. The very rich New River and Pocahontas coal fields near the western terminus are served by the main line and by various branches. The coal from practically all of these mines is collected in the Elmore Yard and hauled to tidewater at Norfolk. The winding Gulf Branch connects with the main line at the north end of the Elmore Yard, which is at Mullens, and much of the coal comes in from this branch where the loaded movement is down grade.

The map and profile, Fig. 1, shows that between the coal receiving yard at Elmore and Norfolk the heavy grades are confined to the section between Elmore and Roanoke. Figs. 2 and 3 show that the curvature on this section is also heavy reaching a maximum of 12 degrees. From Roanoke to Norfolk the maximum grade against loaded movement is only 0.2 per cent and the curvature is not severe. It is,therefore, evident that the track capacity east of Roanoke is much greater than on the section between Elmore and Roanoke. There are some heavy grades against load on the main line north of Mullens but only a part of the coal moves over them because a large portion comes from the main line over the branches which connect east of these grades. All of this means that the section from Elmore to Roanoke is the bottleneck of the system, and if improvements are made to increase the tonnage capacity of this section the remainder of the road can well take care of the increase with very little or no expenditure.

Consideration of traffic growth on the Virginian indicates that the capacity of the coal fields it serves has hardly been scratched and that this coal will be mined with large capacity modern equipment. An over production of coal at the present does not mean that the large capacity high grade mine will curtail production indefinitely but rather that the small capacity mine and all low grade mines may be more or less indefinitely closed. There should, therefore, be in prospect for this road a rapidly increasing tonnage, provided it can be

efficiently conveyed to and handled at tidewater. The Virginian is now installing adequate and efficient pier facilities at Sewalls Point to handle far more coal than can now be moved over the railroad. The general situation is, therefore, available tonnage at one end of the road and facilities for handling it at the other end with an

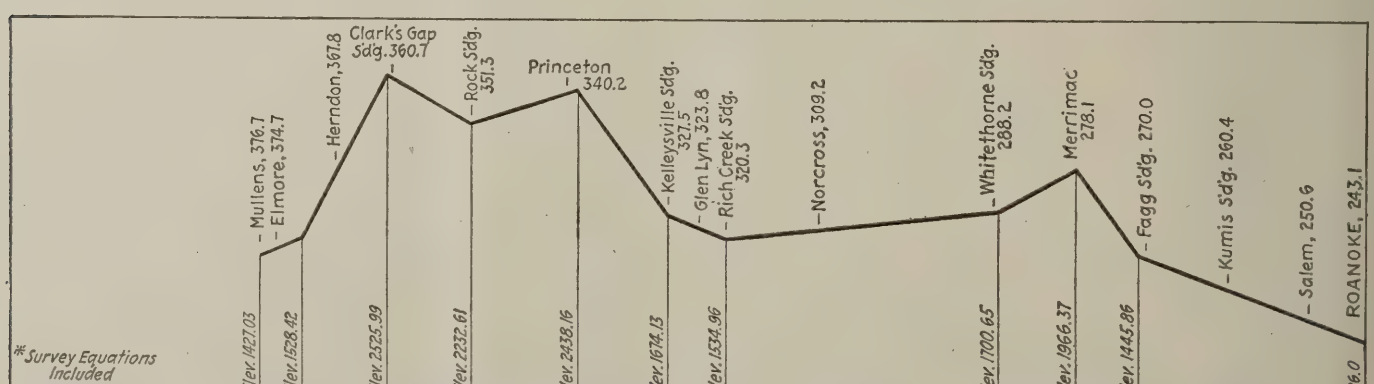
of improvements in rolling stock in order to increase train weights. The road has been a leader in mass transportation and is operating today, on the section to be electrified, heavier coal trains made up of larger capacity cars and hauled by more powerful steam locomotives than are to be found on any other railroad. Experience has shown

Fig. 1—Map and Profile of Virginian Railway

existing conveyor between with ample capacity except for two links, the two engine districts extending from Elmore to Princeton and from Princeton to Roanoke.

The management of the Virginian has long been noted for its broad vision and has been quick to take advantage

that steam locomotives still larger than those now used on the Virginian are not now practicable and that existing draft gear will not permit the handling of materially heavier trains with steam locomotives. In order to increase the capacity of this section with steam operation it



Miles *		5.06	10.32	10.05	12.97	10.90	7.21	32.72	9.51	7.43	27.56	
Compensated Grade Per Cent	East	+.531	+1.979	−.396	+.402	−1.259	−.340	+.168	+.583	−1.252	−.313	
	West	−.228	−1.681	+.710	−.198	+1.395	+.391	−.024	−.415	+1.400	+.401	
Maximum Grade, Per Cent		1.21	2.11	1.25	0.60	1.50	0.808	0.20	0.60	1.5	0.9	
Aver. Curve, Degrees		3.19	3.73	3.93	2.55	1.70	0.64	1.80	1.35	1.85	1.10	
Max. Curve, Degrees		12°	12°	12°	8°	8°10′	3°	8°	8°	8°	8°	
Miles from Norfolk (From Mile Posts)		376.73	371.67	361.36	351.33	338.40	327.49	320.29	287.59	278.10	270.67	243.11

Fig. 2—Condensed Profile of Electrified Zone

would be necessary either to increase the train speed or put down more tracks, or to do both. Additional trackage in this mountain territory with numerous tunnels and bridges would, of course, be very expensive. An increase in train speed could only be accomplished by using more locomotives per train and this would pyramid delays. In any case there would be required for steam locomotives more cost and a material increase in investment.

The alternative to increased trackage and more steam locomotives was electrification. This appealed to the Virginian officials because it offered a means of applying still more powerful locomotives which could be used to haul heavier trains at much higher average speed than is being done with steam motive power and without increasing maximum speeds now common practice with steam operation. Furthermore, the electric locomotive capacity which can be concentrated in a single train can be indefinitely increased. Thus, as rolling stock and track standards are improved—and past experience indicates that they will be—a properly designed and installed electrification can be readily and economically expanded to increase further the track capacity because still heavier trains can be operated or the same trains can be operated at higher speed. It was for these reasons that the officials of the Virginian investigated the possibilities of electrification and quickly recognized in it an excellent solution of the problem of handling more tonnage over the mountain grade sections.

As was to be expected the Virginian management was not unmindful of the future when investigating the economy of electrification. At the time the study was made the net coal tonnage was approximately 7,000,000 tons per year. This represented approximately 50 per cent of the potential capacity of the mines served and extensive development of new mines was being carried on. It was to be expected that the 7,000,000-ton figure would be materially increased after the electrification was in service so an annual net coal tonnage of 12,500,000 was fixed as the basis for comparing the relative economy of steam and electric operation. It was further specified that the maximum day traffic, 60 per cent in excess of the annual average, should be handled. These conditions were to be met with the heaviest trains feasible with the existing rolling stock.

Careful estimates of the investments required to equip the railway to handle the traffic fixed as a basis of comparison with both steam and electric operation and a detailed comparison of operating expenses conclusively showed electrification to be economically advantageous.

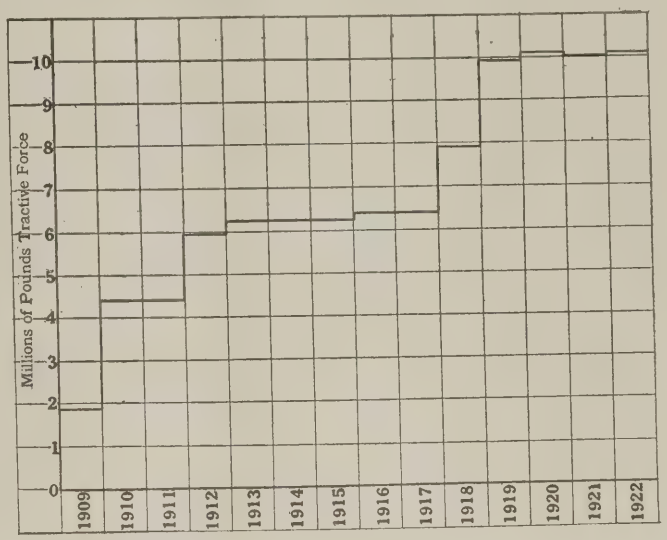


Fig. 4—Total Locomotive Tractive Power

Steam Operation

As previously mentioned, larger and more powerful steam locomotives than are being used by the Virginian are not now feasible. A larger type—a triplex—was once tried. Characteristics of this locomotive are shown in Fig. 6. It has since been rebuilt into two smaller locomotives. Under the present plans of operation with steam motive power, the section being electrified is divided into two engine districts. The main shops of the system are at Princeton, and this point is also an engine terminal. The section from Princeton to Elmore, 35 miles, is one engine district on which turn-around runs are operated out of Princeton. The other engine district extends

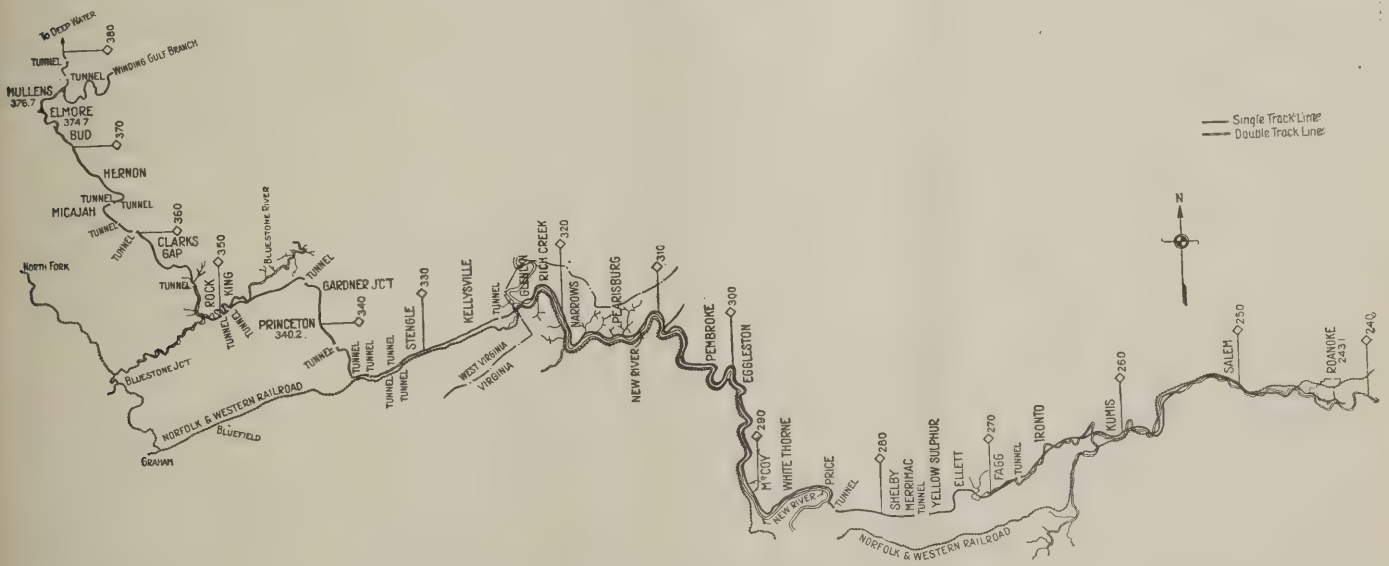


Fig. 3—Map of Electrified Zone

from Princeton to Roanoke, 97 miles. Coal from the mines is collected in the Elmore yard and taken from there to the Princeton yard in trains of a maximum weight of approximately 5,500 tons; total weight exclusive of locomotives. At Princeton all inland consigned coal is weighed and trains of maximum tonnage of approximately 8,500 are made up for movement to Roanoke.

To haul the trains of 5,500 tons from Elmore yard to Clarks Gap requires three Mallet locomotives. The road locomotives is of the 2-8-0 + 0-8-2 wheel arrangement with a cylinder tractive force rating of 101,300 lb.; compound. The weight of the locomotive and tender in working order is 740,000 lb., and the weight on the drivers is 478,000 lb. The two pushers have the 2-10-0 + 0-10-2 wheel arrangement and are illustrated by Fig. 7.. These locomotives which have a cylinder tractive force rating of 147,200 lb. compound have 617,000 lb. on the drivers. The weight of the locomotive and tender in working order is 898,000 lb. From Clarks Gap, the road locomotive takes the train to Princeton. The speed on the heavy grade section with the three locomotive train is approximately seven miles an hour.

From Princeton, the 2-8-0 + 0-8-3 type of road locomotive takes the train to Roanoke with the assistance of a pusher of the same class from Whitethorne to Merrimac and the assistance of yard switchers is usually required to get out of the Princeton yard.

Electric Locomotives

The electric locomotives for the Virginian will be essentially the same as those now being completed by the Westinghouse Company for the Norfolk and Western Railroad. They are of the split phase, constant speed type with one three-phase induction motor driving,

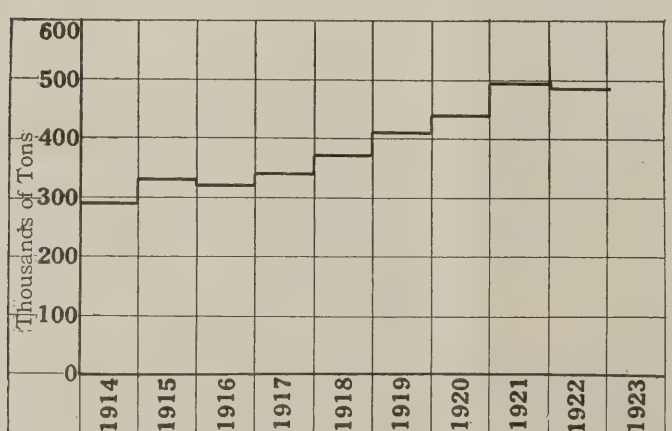


Fig. 5—Total Tonnage Capacity of Coal Cars

through a jack shaft and side rods, two of the driving axles in each truck.

The new Norfolk & Western locomotive which consists of two coupled units is shown in Fig. 8. The Virginian locomotives will differ from this only in certain details. It will be noted that the wheel arrangement is of the Mikado type.

Single-phase, 25-cycle power of a potential of 11,000 or 22,000 volts will be supplied to the transformer on the locomotive through a pantagraph collector which makes contact with the trolley wire. Low voltage power for the three-phase traction motors and for the auxiliaries is taken from the transformer and phase converter. Since the traction motors are of the induction type regeneration is automatically obtained when the train pushes the locomotive on descending grades.

In the Virginian service, three cabs or units will be semi-permanently coupled to form one locomotive. Each locomotive consisting of three units will have a continuous tractive effort rating of 135,000 lb. with 8-pole motor connections and 78,800 lb. with 4-pole motor connections. At these ratings, the speeds will be approximately 14 and 18 miles per hour and the horsepower output 5,100 and 6,000 respectively. The maximum tractive effort which can be developed momentarily at any speed up to 14 m. p. h. is 277,000 lb., and a tractive effort of 252,000 lb.

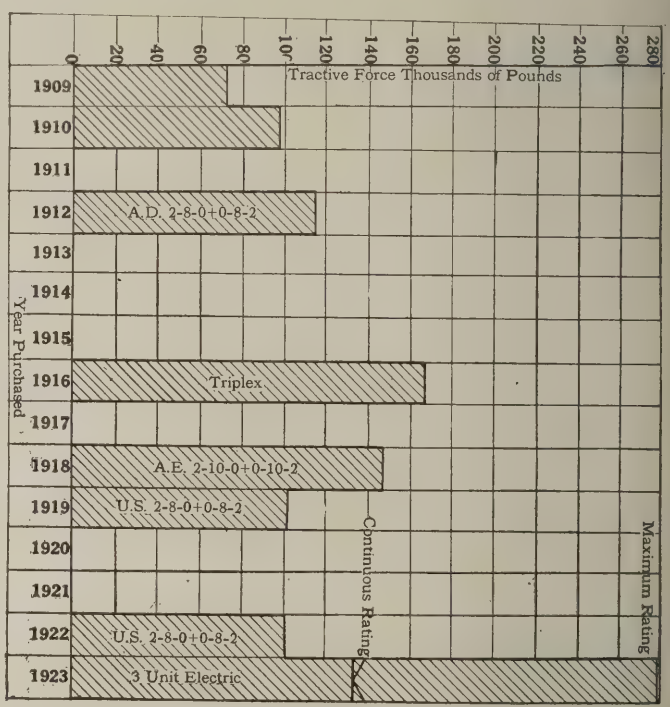


Fig. 6—Tractive Force Rating of Largest Locomotive Purchased

can be developed for a period of five minutes. The total weight of each unit will be slightly in excess of 400,000 lb., with more than 300,000 lb. on the drivers. A performance curve of these locomotives when motoring is shown in Fig. 9. The characteristics when regenerating are similar, the speed rising slightly as the output increases.

Plan of Operation with Electric Locomotives

With electric locomotives the section from Elmore yard to Roanoke can be operated as one locomotive district. Trains of 6,000 tons will be hauled from Elmore to Clarks Gap with one road locomotive and one pusher—each composed of three units. The speed will be 14 m. p. h.—double that with steam—and the horsepower required at the locomotive wheels will be 12,000. At Clarks Gap trains will be filled out to 9,000 tons and taken on to Roanoke by the road locomotive without helper at speeds of 14 or 28 m. p. h. depending upon the grade conditions. The time required for the run from Elmore to Roanoke will be less than ten hours. In comparison with the steam operation, the helper on the Whitethorne grade is entirely eliminated by electrification, the helper service out of Elmore is reduced more than 50 per cent and the time over the road greatly decreased.

The 9,000-ton trains will be held to a constant speed of slightly less than 15 m. p. h. by regeneration when descending the Kellysville and the Merrimac grades. This will, of course, give much smoother operation than is obtained when long trains are controlled with the air brakes alone on these grades and delays will be decreased.

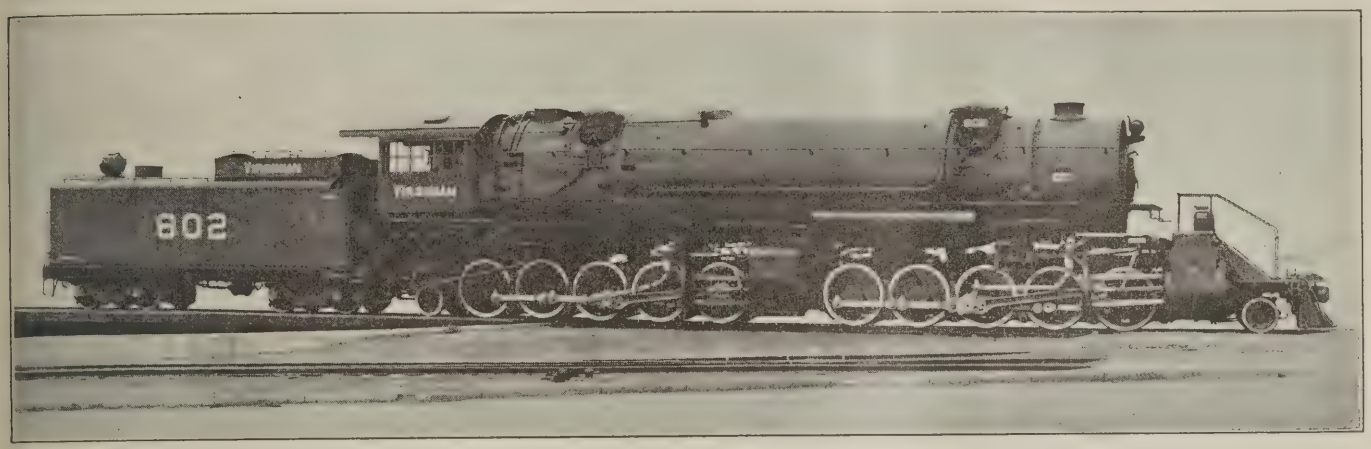


Fig. 7—Type of Mallet Pusher Locomotive, Weighing Approximately 450 Tons, Now in Service on the Virginian

The west bound trains will consist largely of empty coal cars and will be hauled without helpers at a speed of 28 m. p. h. except from Fagg to Merrimac, from Kellysville to Princeton and from Rock to Elmore.

To handle the traffic fixed as a basis for planning the electrification will require 48 locomotive units or 16 three

Fig. 8—The Virginian Locomotives Will Be Very Similar for Those Now Being Completed for the Norfolk & Western

unit locomotives and 12 of these have been ordered for initial operation. To perform with steam locomotives the same service that can be handled with 16 of the electric locomotives the railroad operating officials estimated that 20 of their large pusher Mallet locomotives and 44 of their road type Mallets would be required, and a few more switchers would also be required with steam operation than with electric because the latter will operate through the Princeton Yards. On the basis of these estimates the cost of the new electric locomotives is only about 20 per cent more than the cost of new steam locomotives which would be required for the same service. The total weight of the steam locomotives, in working order, would be approximately 2.5 times that of the electric locomotives.

Power Equipments

When starting on the heavy grade the input from the contact line to a 6,000-ton train will be approximately 14,000 kw. and the 9,000-ton train handled by a single locomotive will require an input of 11,000 kw. when starting on certain grades. With individual train demands of such magnitude and with the high ratio of maximum to average day tonnage the system demand will, of course, be very large. The free movement of traffic will not be subordinated to power demand so the

load factor will be rather low. The traction load five minute demand will be approximately 43,000 kw. at the generator bus and the ratio of this peak to the annual average load will be approximately 30 per cent.

The power for this electrification will be supplied by the railway company's steam turbo-generator station now being installed on the New River at Narrows. The site, by rail, is 23 miles east of Princeton and seven miles west of the middle of the section being electrified. There will be installed in this station four 25-cycle, 3-phase, 11-000-volt, turbo-generators with a maximum single phase rating of 15,000 kw. each. Three units will be sufficient to carry the maximum demand. This station will be thoroughly modern with provision for economical expansion and with switching equipment suitable for ultimate interconnection with other power systems. An ample supply of water for condensing purposes is available from the New River and condensers of the surface type will be installed. A complete pulverized coal equipment will be used in this plant.

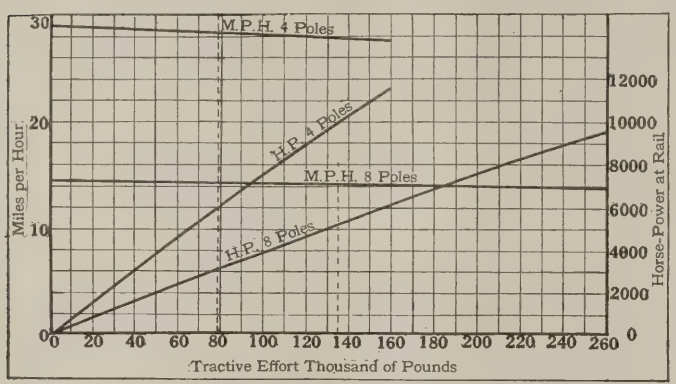


Fig. 9—Electric Locomotive Performance Curve

There will be four 11,000 to 88,000-volt, 10,000-kv.-a., single-phase, water-cooled type transformers installed just outside the power station building. All high tension switching equipment will also be installed outside the main building.

Transmission and Distribution System

Power from the generating station will be supplied to the locomotives through transmission lines, step-down transformers and catenary contact line. There will be two single-phase, 88,000-volt transmission lines connecting the generating station with seven step-down transformer stations located at Elmore, Algonquin, Princeton, Narrows, Eggleston, Merrimac and Sears. These step-down transformers will be of special type with two windings on the secondary. One of these windings will be connected to the 11,000-volt trolley rail circuit and the other to a feeder rail circuit with a potential of 22,000 volts. This gives a secondary transmission circuit composed of

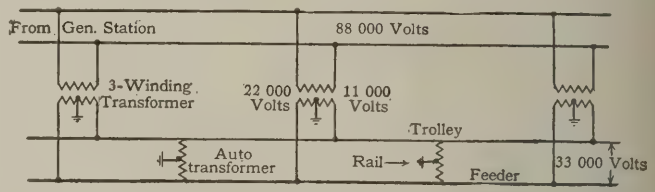


Fig. 10—General Plan of Transmission and Distribution System

the trolley and feeder wires, which is used to supply auto-transformers connected between the main step-down transformer stations. The general idea of this scheme of transmission and distribution is illustrated by Fig. 10. By designing the transformers and the trolley-feeder, trolley-rail and feeder-rail circuits so as to secure the proper balancing of impedance the rail currents are reduced to a minimum and the through feed of earth current and stub-end feed effects are almost eliminated.

The transmission line and distribution circuit conductors will be carried on steel structures. The transmission lines will be on towers separate from the contact line supports except on the Clarks Gap double track section, where they will be carried on the catenary structures. The contact line will be of the inclined catenary type similar in general to that in service on the Norfolk & Western Ry., and on the Paoli electrification of the Pennsylvania R. R. at Philadelphia.

The entire distribution system is designed for a trolley voltage of either 11,000 or 22,000. It will have the necessary capacity to handle the maximum day traffic specified at 11,000 volts, but the change to 22,000 volts can easily be made when the traffic increases to the point where this change is advisable.

The contract was let to the Westinghouse Electric & Manufacturing Company for the equipment and the railroad has retained Gibbs & Hill as consulting constructing engineers.

International Gasoline Passenger Motor Car Built at Sydney, New South Wales

Semi-Annual Meeting of the A. R. E. E.

Progress Reports of the Various Committees to Be Presented for Discussion in Atlantic City on June 12

THE 1924 semi-annual meeting of the Association of Railway Electrical Engineers will be held in Atlantic City on June 12. As in the past the meeting will be held in the Hotel Dennis. This meeting is usually held on a Monday but on account of conflicting with sessions of the American Railway Association at which certain committees of electrical men must be present, it was decided to fix Thursday, June 12 as the day for the A. R. E. E. convention. No meeting of the association was held last June and there are plenty of indications that this year's convention will be well attended. The program is as follows:

ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS

Convention Program

Meeting Room, ground floor, Hotel Dennis, Thursday, June 12, 1924.

Meeting will be called to order promptly at 9:30 A. M. (Daylight Saving Time.)

ORDER OF BUSINESS

Address of President.
Report of Secretary-Treasurer.
Unfinished Business.
New Business.
Progress Report of Committee on Trucks and Tractors.
Progress Report of Committee on Safe Installation and Maintenance of Electrical Equipment.
Progress Report of Committee on Self-Propelled Cars.
Progress Report of Committee on Electric Welding.
Progress Report of Committee on Locomotive Electric Lighting.
Progress Report of Committee on Electrical Storekeeping.
Progress Report of Committee on Train Lighting Equipment and Practice.
Progress Report of Committee on Starters and Controllers.
*Progress Report of Sponsor Committee on Insulated Wire and Cables.
Progress Report of Committee on Economics of Electrical Appliances.
*Progress Report of Committee on Illumination.
*Progress Report of Committee on Radio as Applied to Moving Trains.
*Progress Report of Committee on Automatic Train Control.
*Progress Report of Committee on Power Plants.

Progress Report of Committee on Safe Installation and Maintenance of Electrical Equipment

Committee:—

Charles R. Sugg, Chairman, Electrical Engineer, Atlantic Coast Line. A. M. Frazee, Electrical Engineer, Duluth, Missabe & Northern. L. F. Miller, Road Foreman, Electrician, Chesapeake & Ohio. Frank Zimkowski, General Car Lighting Inspector, New York, New Haven and Hartford.

TO THE MEMBERS:

INSTALLATION

General.

1. All new work should be installed in the safest way possible.

2. Existing installations should in all cases be brought up to safety standards, as soon a practicable.

3. All work must conform to the National Electric Code, and local ordinances.

4. In all cases, where ground connections are required, it is recommended that these connections be made to a cold water pipe, which is known to form a permanent and positive ground. If a cold water pipe is not accessible, it is recommended that a ground connection be made by driving not less than a three-quarter inch galvanized pipe in the earth a sufficient depth to insure a permanent ground. In all cases, approved ground clamps must be used.

5. It is recommended that all new installations shall be made in conduit, and when extensive repairs are made to old installations of open wiring, conduit shall be substituted.

6. It is recommended that all high voltage wiring (601-5000) shall be in lead covered cable run in conduit.

7. Where any installation is not covered by the above, use good judgment to make it safe.

Equipment and Material.

1. Use good reliable equipment, which, as far as practicable, incorporates safety devices, which will protect both operator and equipment.

2. In consequence of liability involved by accident, primary consideration should be given to the safety features rather than to the first cost.

Generators.

1. Frames must always be well grounded.

2. Flywheels and belts should be guarded. Flywheel pits should either be covered or guarded.

Switchboards, Power panels or sub-stations.

1. Systems above 300 volts should be of a dead front type.

2. All switches on circuits above 300 volts should be of the oil type, which have separate contained cells for each pole, and should have proper disrupting capacities, in order to insure the performing of its functions with safety, and properly protect the apparatus to which they are connected.

3. Automatic overload circuit breakers should be installed, between generator and switchboard buses on direct current equipment, but it is deemed advisable to omit these features on alternating current systems.

4. All feeder circuits should be protected with automatic inverse time limit overload oil switches.

5. Switchboards should be so installed that there will be ample space, between conductors and wall, to permit

* Report not received in time for publication in the June issue of the *Railway Electrical Engineer.*

workmen to make repairs with safety; this space to be enclosed behind locked doors.

6. All switchboards not provided with dead fronts should have rubber mats in front and rear of same.

7. Fuses are not recommended where automatic circuit breakers can be used.

Motors and Control Equipment.

1. Strict conformance to the National Electric Code and local ordinances is recommended.

2. Each equipment should be provided with separate safety disconnecting knife switch to disconnect control and motor from line so repairs can be made with safety.

3. All controllers with exposed live parts should be enclosed in safety cabinets with doors so arranged that only authorized persons shall have access to same.

4. Motor starting rheostats should be enclosed in metal cabinets with handles for external operation.

5. All protective devices used in connection with motor control apparatus should be provided with full magnetic or thermo overload and under-voltage protection with hand reset, excepting automatic equipment.

6. Where motors are so installed, that there is a liability of accident, adequate guards should be placed around same to protect workmen. This to include belts, gears or other transmitting devices.

7. The frames of all motors, and each piece of control equipment, must be thoroughly grounded.

8. Caution display cards admonishing danger should be conspicuously placed at such a location as to warn employees and others of the presence of high voltage and equipment.

Wiring.

1. Strict conformance to the National Electric Code and local ordinances is recommended.

2. It is recommended that all new installations be in conduit.

3. When used in connection with portable cords, it is recommended that composition or other well insulated sockets of the keyless type be used.

4. On power circuits adhere strictly to the National Electric Code and local ordinances.

5. For portable equipment other than small hand lights, it is recommended that armored cable or additional wire be used for grounding machine. Where armored cable is used the armor must be so connected that it shall form a grounded connection to the conduit system.

6. For the installation of high voltage equipment, all wiring shall be in lead covered cable running conduit.

7. The installation of extra high potential circuits is adequately covered by National Electric Code.

MAINTENANCE

1. In the maintenance of electrical equipment, it is recommended that thorough systematic periodic inspection be made and any improper or irregular condition be found it shall be repaired immediately.

2. Equipment should be kept thoroughly dry and clean.

3. When inspection is made, it should include the supports sustaining the equipment, which should be kept secure and rigid. All power transmitting devices, such as belts, gears, etc., should be included in this inspection.

4. The inspector should see that all circuits are properly fused and overload relays adjusted and operative.

5. For the safety of repairmen or others, the following suggestions are offered:

Don't work on live circuits, except when absolutely necessary, then take proper precautions.

Don't work on high tension apparatus until you are sure it is positively disconnected from line.

Don't place tools or other loose objects, where they are liable to fall and cause damage or accident.

Don't feel a circuit to see whether it is alive or not, but use lamps or meter instead.

Don't oil, wipe or adjust machines while in motion.

Respectfully submitted,

COMMITTEE ON SAFE INSTALLATION AND MAINTENANCE OF ELECTRICAL EQUIPMENT.

Progress Report of Committee on Power Trucks and Tractors

Committee:—

Louis D. Moore, Electrical Engineer, Mo. Pac. R. R. Co. (Chairman). C. G. Winslow, Assistant Electrical Engineer, Michigan Central R. R. Co. J. W. Hughes, Electrical Engineer, Canadian Pacific Ry. Co. E. W. Jansen, Electrical Engineer, Illinois Central R. R. Co. T. F. Foltz, Electrical Engineer, Washington Terminal Co.

TO THE MEMBERS:

Your committee has held two meetings, one at Detroit on January 24, and the other at Chicago on March 11.

At these meetings a sub-committee on crane type trucks for roundhouse and shop use was appointed and a new questionnaire on operating costs prepared and discussed. This questionnaire is based on the cost outline previously reported by the committee and is intended not only to obtain revised costs, but to ascertain the method by which they are figured. This questionnaire will be submitted to the operating heads of the various roads very shortly.

The sub-committee on crane trucks has not as yet made a report.

The general committee was fortunate at both meetings in being able to inspect exhibits of various types of trucks and tractors at the Detroit Motor Show and the National Railway Appliance Show in Chicago, and also was able to observe a crane truck in actual service at the West Detroit Shops of the Michigan Central Railroad Company. The committee would like to have an active discussion of the following points relative to its subject.

1. General use of crane type electric trucks in roundhouse work. What operations are most usually performed with it? What is the comparative cost with this type equipment, manually operated equipment and overhead cranes? Does it require a large house to justify the expenditure for this type of equipment?

2. To avoid heavy discharge of batteries, is it the practice to make use of lifts or hauling machinery to help electric trucks over steep grades?

3. Discussion as to merit of worm gear and spur gear drive. Several manufacturers have gone to the spur gear drive, claiming that because of greater efficiency smaller batteries can be used, while others claim they have tried the spur gear and have found it to be noisy and that its average efficiency throughout its life is less than that of

the worm gear. What has been the experience of the members?

4. Is the expense of equipping electric trucks with ampere hour meters justified?

5. Have any members used overload circuit breakers on electric automotive equipment and with what success?

6. Is the expense of mileage recording devices, such as odometers or speedometers, generally justified?

7. Details entering into cost per kilowatt hour for charging current at the charging plug.

8. What is general experience of members with use of various types of gasoline equipment compared to electric equipment; (a) in shops, engine houses and storerooms; (b) in freight houses and on docks? Have the fire insurance companies made any difference in premiums because of use of gasoline equipment? Have any fires been caused by such equipment directly or indirectly?

9. What has been the experience of members regarding long trains of trailers behind tractors in freight house work? Cannot freight be handled just as quickly and economically, or even more so, by limiting the length of the train and the weight of the trailing load? What is considered an economical length train in ordinary freight houses?

The subject of power trucks and tractors is of growing importance because their use is increasing very rapidly and your committee solicits a full discussion.

Respectfully submitted,

COMMITTEE ON POWER TRUCKS AND TRACTORS.

Progress Report of Committee on Self-Propelled Cars

Committee:—

R. G. Gage, Chairman, Electrical Engineer, Canadian National Railways Company. E. Wanamaker, Electrical Engineer, Chicago, Rock Island & Pacific Ry. L. L. King, Electrical Engineer, Atchison, Topeka & Santa Fe R. R. E. S. Macnab, Engineer Car Lighting, Canadian Pacific Ry.

TO THE MEMBERS:

Your committee has not, up to the present time, had sufficient opportunity to investigate and study the problem of self-propelled cars to the extent of making any definite progress report, but offers, at this time, a short progress report showing that this subject is from all appearances active on a number of railways at the present time, but has not undergone any marked change since this committee made its report at the annual meeting in Chicago last November. However, more railroads have become interested, and further types of cars are being developed, but it does not seem that any marked advance in our knowledge of the unit car has been made.

As evidence of the activity of this subject, we may point out that the Canadian National Railway has increased its storage battery cars by six, the Canadian Pacific Railway has placed one car in operation, and that the T. & N. O. is purchasing a battery car. Besides the storage battery car, the Canadian National Railways are carefully watching the development of the gas-electric and Diesel-electric cars, several of which are actually being built.

Two storage battery cars are being put in operation on the Central Vermont, while additional gasoline cars have been put in service on some of the eastern roads.

The three developments which appear to be of the greatest interest at the present time among the American cars, are the hydraulic transmission as installed on the gasoline car of the N. Y. N. H. & H. R. R.; the gasoline car with multiple unit control, as being manufactured by the Mack Truck Company, Allentown, Pa., in which a separate gasoline engine is mounted on each truck beneath the car floor, and the two engines in each car, or the several engines in a multiple unit car train, are operated by electro-pneumatic control. Up to the present time, a car of this type has not been put in regular service, and it will be interesting to note the life that is obtained from the standard truck transmission which is used.

The third car of interest is the gasoline-electric which is being built by the Electro-Motive Engineering Company of Cleveland. In this, the power plant will consist of a motor generator set mounted on the floor, the car being driven by motors on the car axles in the usual manner.

Considerable interest is also being shown in the development of the Diesel-electric car, both by manufacturers and railways.

It would seem that before the annual meeting, this committee will be able to collect performance data on these several cars, which will be of great comparative interest.

It is the committee's intention to obtain full information on a test run of each of the battery cars on the Canadian National. After this is done, and co-related with the various profiles over which the cars are operating, very reliable energy consumption records should be available.

Respectfully submitted,

COMMITTEE ON SELF-PROPELLED CARS.

Progress Report of Committee on Electric Welding

Committee:—

E. Wanamaker, Chairman, Electrical Engineer, C. R. I. & P. R. R. F. J. Hill, Chief Electrician Michigan Central R. R. C. E. Murrey, E. E., Grand Trunk R. R. C. T. Goddard, General Foreman, Electrical Department, I. C. R. R. Ernest Lunn, E. E., The Pullman Co. E. H. Hagensick, E. E., Union Pacific R. R. J. C. McElree, E. E., Missouri Pacific R. R. R. C. Gage, E. E., Canadian National Rys. A. M. Frazee, E. E., Duluth, Missabe & Northern Ry. Co.

TO THE MEMBERS:

Your committee begs to report that three meetings of the committee have been held in Chicago with fair average attendance, considering the heavy demands being made upon the time of the electrical men at this period of the year. The consensus of opinion has been such that the committee is making to the Association the following recommendations:

In view of the fact that the electric arc welding process has some time since passed the experimental or development stage and has become a recognized commercial art or practice, it is deemed extremely advisable for this association to compile an electric welding manual. The de-

sign and manufacture of electric welding equipment and the installation of same has been treated by the Electric Welding Committee each year for the past several years; also some work has been done on the application of the process.

The manual, as proposed, should start with a foreword explaining the chief reasons for the compilation and existence of such a manual, with the proper explanation to the effect that the Electric Welding Committee will be a standing committee and each year its work to consist of such revisions as are necessary work to maintain the manual up to date.

In this case, it is felt that the manual should cover the forms of electric welding processes used in railway work, including arc welding, both metallic and carbon, spot welding and resistance welding. The manual to be so indexed, possibly using the method of indexing of the American Locomotive Company, that the manual may be used as a book of ready reference for the entire art. It is realized that it would not be possible to make a complete manual during the year 1924; however, it is recommended that a progressive start be made and work to continue into 1925, issuing the manual either in part as completed with the necessary additions, or complete the same in 1925 according to the decision to be arrived at after the report is made at the Annual Fall Convention.

It is probable that the *first* section of the manual will consist of a description of the various electric welding processes and their general use. The *second* section to consist of recommended methods of installation. The *third* section to consist of recommended methods of application covering first the typical jobs and important jobs that have already had their successful application demonstrated by years of service, including detail instructions for the training of operators.

The last section to consist of description of application of such jobs as are being experimented upon or such jobs as are undergoing development in so far as the welding application is concerned.

It is the intention on all such practices as have not been thoroughly tried and developed into a standard, to send out proposed methods or practices to various railroads, obtaining the opinions of the various mechanical and welding officers so that no practice will be recommended that has not been demonstrated and approved. This, in order, that the manual may be so compiled that it may be looked to for safe advice or recommendation to guide the users of the art in their daily work. Of course, it is to be understood that such practices as are recommended would be one safe way of performing the work, and the user is not necessarily limited to the recommended practice.

From time to time as better practices are developed and proven, bulletins, or new sheets, will be issued.

We already have collected the nucleus for compiling this manual, which the committee feels should be of the loose leaf type, preferably of standard letter size with the back or hinge on the side. As it becomes necessary to issue new bulletins, those replaced may be removed and the new bulletins inserted, or in case of additional bulletins, they may be inserted in their proper place according to the index. The type of indexing proposed will enable the users to quickly find under group headings any particular class of welding application desired, each group subdivided into individual jobs of that particular kind or class.

It is also the intention of the committee, in the foreword, to call attention to the importance of the part the operator's skill plays when applying the autogenous welding practices.

It is further recommended that sections on electric arc cutting, rivet heating, and electric furnaces, be included in the manual.

If the recommendations hereto suggested are approved by the semi-annual meeting, the committee will arrange to proceed with the compilation of the manual.

Respectfully submitted,

COMMITTEE ON ELECTRIC WELDING.

Progress Report of Committee on Locomotive Electric Lighting

Committee:—

L. C. Mulheim, (Chairman) Chief Headlight Supervisor, Baltimore and Ohio Railroad. J. L. Minick, Assistant Engineer, Pennsylvania System. P. J. Callahan, Superintendent Car and Locomotive Lighting, Boston & Maine R. R. E. Wanamaker, Electrical Engineer, C. R. I. & P. R. R. F. J. Hill, Chief Electrician, Michigan Central R. R. Wm. Hirsch, Chief Electrician, N. Y. C. & St. L. R. R.

TO THE MEMBERS:

General instructions to your Committee were to continue the investigation and development of the subject of Locomotive Electric Lighting, following up the work of last year's Committee and working in close co-ordination with the Committee on this subject of the American Railway Association.

An effort has been made to follow up the work of last year and some progress can be reported. The matter of developing a standard method of making photometric tests of headlight reflectors has been given further consideration and one of the roads, for the purpose of obtaining information relative to the comparative beam candle power of several glass reflectors, conducted two tests. The first test was made along the lines suggested by your Committee of last year, with measurements made on the basis of the 50 foot photometric distance, while the second test was made on the 100 foot photometric distance. A standard 250 watt, 32 volt, G-30 bulb headlight lamp was used throughout the tests, the lamp being operated at rated volts and the results corrected to 4,625 lumens. In test No. 1 the lamp was focused for maximum beam intensity and photometric measurements were made across the beam. A dull black screen was used, upon which the beam was focused, the headlight being placed upon a rotating table which was used to move the beam across the photometer test plate. A Macbeth illuminometer was used to measure the candle power. The results are tabulated below, the beam candle power figures being given for one foot intervals across the horizontal center line of the beam. The upper half of the beam was also analyzed by taking candle power measurements at one foot intervals from the center, up along the vertical axis. The column marked "0" feet gives the beam candle power on the projected axis of the beam. Figures to the right of this column represent measurements at one foot intervals along the horizontal line across the curtain through the intersection of the projected axis and the screen, and to the left, viewing the screen from the headlight position.

TEST No. 1

Results expressed as $\frac{\text{Beam C.P.}}{1000}$

Distance From Center of Beam as Viewed From Headlight Position

	3′	2′	1′	0′	1′	2′	3′
Reflector—A.....							
14″ Diameter							
Focal Length 2½″.....	79	135	166	254	160	75	39
	Above Center			254	126	81	50
Reflector—B	3	325	383	595	329	38	8
14″ Diameter	Above Center			595	239	85	20
Focal Length—3″							
Reflector—C							
14″ Diameter	138	354	329	370	251	63	19
Focal Length 2¼″....	Above Center			370	248	88	31
Reflector—D							
14″ Diameter	63	119	210	344	285	103	38
Focal Length 2½″.....	Above Center			344	160	104	54

In test No. 2 with the 100 foot distance, the same Macbeth illuminometer used in test No. 1 was employed, and as a further check on the results a Sharp-Miller photometer was also used. These instruments were moved across the beam at their respective distances from the headlight, this method being considered more accurate than rotating the headlight. The curtain was ruled off with white lines, one foot apart horizontally and vertically, and an analysis of the beam was made horizontally across a diameter of 10 feet. The same letters are used to identify the reflectors in each test and the results obtained are as follows, test No. 2 being carried out two feet farther each way from the center than test No. 1.

TEST No. 2

Results expressed as $\frac{\text{Beam C.P.}}{1,000}$

Distance From Center of Beam as Viewed From Headlight

	5′	4′	3′	2′	1′	0′	1′	2′	3′	4′	5′
Reflector—A.....											
14″ Diameter..	61	83	110	139	190	187	178	179	161	148	131
Focal Length 2½″											
Reflector—B											
Focal Length 3″	54	94	109	130	162	222	228	244	348	250	89
Reflector—C ...	62	92	159	242	376	555	393	250	167	91	34
Focal Length 2¼″											
Reflector—D ...	138	149	191	249	247	222	217	157	116	94	65
Focal Length 2½″											

Considerable variation in the readings will be noted not only for the same reflector in tests 1 and 2 but in the readings for a certain reflector in the same test, showing in some instances much higher candle powers in some of the outer zones on the screen than in the center of the projected beam. This may be due to imperfect focusing or to characteristics in the lamp used.

In conjunction with these tests, an additional test was made for the purpose of determining the loss in beam candle power of a reflector in an unclean condition from its clean state. The reflector tested was also of glass and had been in service for 15 months without having been cleaned. The results of this test were as follows:

TEST No. 3

Distance From Center of Beam as Viewed From Headlight

Results expressed as $\frac{\text{Beam C.P.}}{1000}$

	5′	4′	3′	2′	1′	0′	1′	2′	3′	4′	5′
					Before Cleaning						
Reflector E											
Focal Length 2¼″	78	106	150	194	228	274	239	207	164	115	87
					After Cleaning						
In service 15 months without cleaning..	86	118	164	213	278	282	235	205	155	114	93

The results of this test would tend to show the possibilities of allowing glass reflectors to go for long periods of time, without cleaning, resulting in a considerable saving of labor and an accompanying saving in lamps, a considerable number of which are no doubt broken in handling while cleaning reflectors. The length of time reflectors could safely be permitted to go without cleaning, of course, must depend upon the condition of the headlight cases and their ability to exclude dirt and moisture. The results of tests 1 and 2 are given as a matter of information obtained from experiment, and will serve to illustrate the difficulty that is quite apt to be experienced by the average railroad in attempting to secure accurate photometric data for comparative purposes without suitable facilities and a standard detail method. It is the hope of your Committee, however, that during the coming months the differences now existing as to the method which is the proper one to adopt can be reconciled and that a satisfactory method can be offered for adoption by the time of the October convention.

Headlight and Cab Lamps

The matter of locomotive lamps has been receiving special attention by some of the roads where it has been found that trouble was being experienced with both headlight and cab lamps, although operating under normal voltage conditions. With the 250 watt headlight lamp investigation developed certain inherent weaknesses in some makes, including brittle filament material, which resulted in early failures and very poor lamp performance. A large number of lamps were found to fail within a few moments after applying and with the locomotive standing at the terminal preparatory to departure. The extent of early failures and the general abnormally short life has resulted in seriously increased consumption on various roads, which is reflected not only in increased maintenance costs but also in train delays, many of which would not have been experienced had the lamps been of normal character. The manufacturers have endeavored to remove and correct the weak features by certain changes in the characteristics of the filament wire and also in the manner of its mounting. Since the changed construction some improvement has been noted, although early failures with the new construction are still being experienced, indicating that the difficulty has not yet been entirely overcome.

In connection with the matter of headlight lamp failure it is felt that it would be well to know just when the filaments actually fail and your Committee desires to conduct an investigation with this object in view by sending out, in the near future, a questionnaire of suitable form to collect this information. It is obvious that incandescent lamps must eventually fail due to failure of the filament, either when the lamp is burning or when it is cold. It is the desire therefore to develop from an investigation to what extent the filament fails; when the lamp is being used in actual service while train is en route, when the current is first turned into the lamp, when the current is turned off the lamp, when the locomotive is at the terminal and the lamp is not in service—for instance, when jarring over a turntable, or under other conditions. It would be well for those members having jurisdiction over the headlight equipment on their respective roads to begin to give the matter some attention with a view to having some information available when the questionnaire is received.

A development of the 250 watt headlight lamp in a smaller bulb, since the October convention, consists of making this lamp with a P-25 bulb instead of the G-25 bulb to overcome the objections to the latter resulting from its similarity to the 100 watt lamp for switching service. A number of the P-25 bulb lamps have been supplied by the National Lamp Works and these are under observation in service and are being compared with

the present standard G-30 bulb lamps. It is the understanding the new P-25 lamp is now commercially available and it is recommended that this lamp be tried out on a sufficiently large scale to determine during the next few months as to whether or not it is satisfactory and more desirable than the present G-30 lamp.

The new cab lamp in S-14 bulb is being tried out rather extensively and at this time it is doubtful as to whether or not this lamp in its present state of development is an improvement over the S-17 bulb so far as life performance is concerned. The advantages of its smaller proportions are quite evident but while trial results in some instances seem to indicate a better lamp than the S-17 bulb experience in other instances seems to show that this lamp does not compare with the S-17 lamp in life performance. A comparative test of the two types is being run on one of the roads, in which an accurate check is being kept on their performance, and it is expected that reliable information will be secured in the near future on the basis of this as one individual test. The lamp manufacturers state that the matter now is largely up to the railroads as the lamp engineers have gone as far as is possible in the development of the S-14 lamp and any further improvement will have to be brought about through information supplied by the railroads as a result of their experience with the lamp on a reasonably extensive scale. It would be well therefore for the roads to investigate this lamp thoroughly so that during the next few months it can be definitely known if possible whether or not the S-14 bulb lamp is a sufficiently improved lamp to be adopted in preference to the present S-17 bulb.

Fixed Focus for Locomotive Headlights

Recent developments tend to show the possibility of introducing a fixed or permanent focusing device for the headlight. This idea rendering non-adjustable the reflector lamp stand would compel proper headlight case alignment if properly carried out, and would effect considerable improvement in track illumination by preserving the sharpness of the headlight beam after being focally established in the reflector, which is at present unsatisfactory in many cases due to adjustment of the lamp, splitting the beam, in attempting to get the maximum amount of light on the track to overcome misalignment of the headlight case. The headlight lamp furnished today is sufficiently uniform in construction, it is felt, to permit of a fixed focus and if proper alignment of the headlight on the locomotive can be secured it would seem that considerable advantage could be derived from the fixed focus principle.

One of the roads is experimenting with the idea on a rather extensive scale and it would be of interest and value if similar tests could be carried on by others. Your Committee would be glad to receive any information on the subject that is secured as a result of such tests.

The subject of roller bearings for headlight generator service continues to be given attention and one of the headlight manufacturers has obtained very satisfactory results from several installations of this type of bearing. More extensive tests are being run by this company under actual service conditions and indications point to entirely successful operation. While certain makes of turbo-generators may be peculiarly adapted to the use of roller bearings it may be possible that with some slight modification in the present design of other makes this type may be found to be applicable and to possess advantages over the ball bearing that would justify its use. It is suggested, therefore, that the various headlight manufacturers give thorough consideration to the subject and that they develop such possibilities as the roller bearing may have in the way of its adaptability to this character of service.

A number of service tests of headlight generators have been carried on during the past year, wherein the latest types of the various makes of machines have been operated on some of the roads on a comparative basis. The results of these tests, when finally available, will be of considerable interest, not only as a comparison of the newer design of machines themselves but as a comparison showing the improved service of the more modern equipment over that of the earlier types of machines. While the new designs have their respective merits, and despite all excellent showing that may have been made by any certain equipment, the matter of selection for possible future standard is very difficult to determine, and will no doubt remain so until such time as the Automatic Train Control subject is satisfactorily cleared up and the railroads know what character of equipment will be required to meet the conditions.

Respectfully submitted

COMMITTEE ON LOCOMOTIVE ELECTRIC LIGHTING.

Progress Report of Committee on Starters and Controllers

Committee:—Geo. W. Bebout, Chairman, Electrical and Shop Engineer, C. & O. L. L. King, Electrical Engineer, Atchison, Topeka & Santa Fe. J. E. Gardner, Electrical Engineer, C. B. & Q. G. T. Goddard, General Foreman Electrical Department, Illinois Central. F. M. Reed, Chief Electrician, Northern Pacific.

TO THE MEMBERS:

Your committee on controls has had two meetings at Chicago, one to outline the work of the individual members, one to study and discuss the work done and outline the plans of the committee for further study, and recommendations on controls and their application for railroad service.

It is not the desire or intention of this committee to draw up specifications for the manufacture of controls, but to outline important features that should be incorporated in controls, and make recommendations for standard types to be used for various operations in railway service.

When one considers the wide number of types, styles and variations in controls for any operation, he can readily see the need for some standard being adopted.

For one small lathe there would be 98 possible combinations of motor and control from which to select one suited to the work, but this is usually left to the machine manufacturer, with 97 chances of getting the wrong equipment. If manual control is wanted, instead of automatic, the 98 would be cut in half—if reversible, in place of non-reversible, the 49 would be cut in half, and by properly specifying what should be furnished, the type of controls would be reduced to the minimum.

It has been recommended by the committee that manufacturers' representatives meet with the committee at our next conference, to discuss the various features desired in controls.

The following recommendations are up for consideration:

1. In view of the great expense of fuses and liability of single phase operation, controls should be protected by circuit breakers, overload and under-voltage protection, with arrangement to prevent single phasing. Whether undervoltage release with automatic reset, or undervoltage potection with manual reset feature, is to be provided, shall be left to the judgment of the party ordering the equipment.

2. Turntable controls to be manually operated, reversible drum type, and where two motors are used on turntable tractors, Duplex Drum control is to be used.

3. All controllers to be as near dust and weatherproof as possible.

4. All controllers to be equipped with fasteners to hold the covers securely, yet be easily removed without the use of tools.

5. Wearing parts to be accessible and easily replaced.

6. Each terminal to be plainly and permanently marked, and wiring diagram to be securely fastened to inside of cover.

7. The sizes of various motors to be tabulated and two or three sizes of controller be selected to cover the entire range—one for motors from 5 to 10 hp.—one for 15 to 25 hp., and one for 30 to 50 hp., inclusive, in order to reduce spare parts to a minimum.

8. Pumping plant controls to be designed for operation with a large variation in voltage, preferably with time limit acceleration, especially for slip ring motors.

9. To be designed for continuous operation in any accelerating position.

10. Pumping plant motor controls to be hand start and automatic stop.

11. Full automatic start and stop.

12. Where single pumping equipment is installed at important locations or for heavy duty service, duplicate controls to be installed in connection with a double throw switch.

13. Float switch control is recommended for moderate climates, but pressure regulator controls, where winter conditions are severe and where pressure gage controls are used, should be connected to a reservoir or stand pipe partially filled with air, to protect it against surges.

14. Air compressor motors to be slip ring or synchronous, with manual or automatic control, as desired—the automatic control to be operated through pressure gage or regulator, with addition of unloading device, preferably of the governor type that keeps the compressor unloaded until up to speed.

Controllers are to be studied and recommendations submitted for discussion at the October convention, when we hope to have final recommendations adopted by the Association.

Respectfully submitted,
COMMITTEE ON STARTERS AND CONTROLLERS.

Progress Report of Committee on Electrical Storekeeping

Committee:—Edw. Wray, Chairman, Ry. Purchases & Stores, Chicago, Ill. Geo. B. Colegrove, Chairman, Elec. Ill. Cent. R. C. Raether, Asst. Chairman, Elec. Mich. Cent. Ray A. Dean, Elec. Inspr. Pullman Co. H. C. Geimer, Elec. S. K., C. & N. W. H. A. French, Elec. Fore. Santa Fe.

TO THE MEMBERS:

Your committee held one meeting at which it was decided to send a questionnaire to the various railroads to procure information as to the present practice being followed in maintaining stocks of electrical materials and also to secure recommendatons as to improving practice.

This questionnaire will be sent to the chief electrician or electrical engineer, signal engineer and to the general storekeeper of all Class I roads. Your committee will appreciate further suggestion which may be incorporated into a supplementary questionnaire to be sent out at an early date.

Respectively submitted,
COMMITTEE ON ELECTRICAL STOREKEEPING.

Questionnaire

Name Railroad .....

1. Are your stocks of electrical material stored separately from mechanical department stocks? .....

2. Do you maintain a special electrical section at the general storehouse? .....

3. What official has supervision over stocks of:

(A) Electric Car Light Material .....
(B) Headlight Material .....
(C) Signal Material .....
(D) Shop and Terminal Lighting & Power Material .....
(E) Electrical Construction Material .....

4. Do you maintain sub-stocks at local points of:

(A) Electric Car Lighting Material .....
(B) Headlight Material .....
(C) Signal Material .....
(D) Shop and Terminal Lighting & Power Material .....
(E) Electrical Construction Material .....

5. Is this sub-stock material charged off the stores records when received in sub-stock? .....

(A) Is it included in the annual inventory of stock? .....

6. Is Master Stock Book system employed in keeping stock records? .....

(A) If not what system of records do you employ for each of the above stocks (Please send forms) .....
.....

(B) Is the classification of this material in accordance with the A. R. A. Div. VI. material classification? .....

7.(A) Assuming that the electrical department gets real service and co-operation from the stores department, what would be your recommendation as to the best method of maintaining electrical stocks? .....
.....

(B) Assuming that the signal department gets real service and co-operation from the stores department, what would be your recommendation as to the best method of maintaining signal stocks? .....
.....

(C) If the stores department could get full co-operation of the electrical and signal departments, what would be your recommendation as to the best method of handling electrical and signal stocks? .....
.....

8. If you have what you consider good facilities for your electrical stores, won't you kindly send a description with plan, sketch or photo of the layout? .....
Name .....
Title .....
Railroad .....

Progress Report of Committee on Train Lighting Equipment and Practice

Committee:—Ernest Lunn, Chairman, Electrical Engineer, Pullman Company. L. S. Billau, Assistant Electrical Engineer, B. & O. F. J. Hill, Chief Electrician, Michigan Central. D. J. Cartwright, Electrical Engineer, Lehigh Valley. J. L. Minick, Assistant Engineer, Motive Power Division, Pennsylvania. A. E. Voigt, Car Lighting Engineer, Atchinson, Topeka & Santa Fe. J. J. Hack, Engineer Train Lighting, Heating and Ventilation, Southern Pacific. E. S. M. Macnab, Engineer of Car Lighting, Canadian Pacific. A. E. Ganzert, Electrical Supervisor, C. R. I. & P. R. E. Gallagher, Assistant Electrical Engineer, L. & N.

To the Members:

Your Committee on Car Lighting Equipment and Practice submits the following Progress Reports on subjects which have, and are to be considered by the committee during the year.

Design of Battery Boxes

Present day practices indicate that greater clearance above batteries than that provided in the Standard Practice for Battery Boxes and Trays is desirable. Your committee is investigating this subject and anticipates having recommendation ready for presentation at the next Convention.

Some of the railroads are finding that a marked saving can be made in storage battery maintenance expense by providing battery boxes of sufficient depth to permit the cells being flushed without making removal of the trays from the box necessary. It is found that the saving noted results from a reduction in labor required for handling and in lessened damage to crates, cells and connectors.

A deep battery box makes it possible to change the dimension of the battery cells and employ a tank having more sediment space, which permits a lengthening of the period between cleanings. A decided saving appears to be possible by this practice. It is reported that batteries which ordinarily require cleaning about every 18 to 20 months can safely be kept in service for from 36 to 48 months without being removed from the car. Further advantage can be taken of additional head room by increasing the depth of the acid space over the tops of the plates and thus increase the flushing periods with a corresponding decrease in labor.

The question of impregnating the wooden battery crates has been given consideration and it is probable that full particulars can be presented at the annual convention. Advance information appears to confirm the prediction that the paraffine treatment, if properly given, will greatly prolong the life of the wood and make crate renewal less frequent. In order that railroads that have not already taken steps to install the paraffining tanks may be advised as to what had proven to give the best results the following detail method of procedure is presented.

1. Immerse the wood crate complete, with hardware and porcelain parts attached, in a tank of paraffine kept at a temperature of from 240° to 250° F. for from forty-five minutes to one hour, or until bubbling has stopped, indicating that the moisture in the wood has been converted to steam and driven off.

2. Remove the crate from the super hot paraffine and *immediately* immerse it in a tank of the same material kept at a temperature of from 140° to 160° F. for from ten to twenty minutes, or until the wood of the crates has had time to cool throughout to the temperature of the wax. It is essential that this be done as well as that the temperature of the second tank be kept down to about 150° otherwise the impregnation will be incomplete and there will be little evidence of paraffine on the surface of the wood.

3. If after the crate has been removed from the second tank and allowed to cool, there does not appear to be sufficient wax on the surface of the wood to make a perceptible coating, it should be dipped again for only a moment in the cool tank.

Axle Generator Belt-Drive

Last year's report made reference to the use of barrel type axle pulleys of two lengths, 33½ inches and 28½ inches. Of these pulleys the latter length is being used in preference, principally on account of clearance required for application and fastening.

The subject of axle generator drive is being followed up closely. In last year's report reference was made to pulleys of various disigns including a universal type. It will be of interest to know that various railroads are applying about fifty of these pulleys this summer and something more than experimental data may be expected by early fall.

A few installations in which a silent chain drive is employed are being watched and it may be possible to report favorably on that, especially for use by railroads where an excessive amount of snow is encountered. It is reported that chains and sprockets last about two years, or 140,000 to 160,000 miles, and that the maintenance cost considering the positive drive is not excessive.

Car Lamps

As noted in last year's report, member roads recommended adding to the list of recommended lamps the following sizes and types:

25 Watt, 30-34 Volt, PS-16, Gas filled.
100 Watt, 30-34 Volt, PS-25, Gas filled.

On account of the quite extensive use of these lamps your Committee would recommend their adoption as recommended practice.

Fusing Pilot Lamps to Prevent Fire

A member has recommended that pilot lamp circuits be fused. Your Committee does not believe that this is necessary.

Coach and suburban car lighting is being followed as closely as time and opportunity will permit and it is hoped that some worth while information will be available for the annual report.

Consideration is being given to the question of publishing a working manual of standards covering axle generator construction and its accessories.

It is not the purpose of the Committee to report gen-

erally on details of maintenance practice, which are covered at intervals in articles published in trade journals, but it is proposed that mention be made of money saving schemes or devices which can be employed to reduce repair or operating costs.

Respectfully submitted,

COMMITTEE ON TRAIN LIGHTING EQUIPMENT AND PRACTICE.

Progress Report of Committee on Economics of Electrical Appliances

Committee:

E. A. Lundy, Chairman, E. A. Lundy Company.

J. A. Andreucetti, Asst. Elec. Engr., Chicago & North Western Railway.

G. W. Bebout, Elec. Engr., Chesapeake & Ohio Railroad.

E. H. Hagensick, Elec. Engr., Union Pacific Railroad.

R. G. Gage, Elec. Engr., Canadian National Railways.

Geo. E. Murray, Mech. & Elec. Engr., Grand Trunk Railway.

TO THE MEMBERS:—

Your Committee submits the following as the progress report.

The association has for some time felt that if the various economies that are being effected by electrical applications were brought to the attention of railway officers, that a greater appreciation for this end of the work would follow.

It was with this thought in mind that this committee was appointed. The outline of work includes the collection of specific data showing economies that have been brought about by utilizing electrical energy for operating railway facilities.

One committee meeting has been held and a tentative questionnaire has been drawn up which is printed herewith. A thorough discussion of this questionnaire will be very helpful in whipping the final form in shape.

Your committee invites criticism and discussion, also suggestions of features that might be included with this subject.

Respectfully submitted:

COMMITTEE ON ECONOMICS OF ELECTRICAL APPLIANCES.

TENTATIVE FORM FOR QUESTIONNAIRE

1. *Pumping Stations*

Number of stations electrically equipped to replace gas, steam or other drive .....

ANALYSES OF ORIGINAL RECOMMENDATIONS

No. stations where better service was a controlling factor.....
No. stations where decreased maint. was a controlling factor.....
No. stations where labor saving was a controlling factor.....
No. stations where fuel saving was a controlling factor.....
No. stations where saving in fixed chgs. was a controlling factor.....
Bearing in mind the reduction in labor, repairs, etc., please give the following for at least one installation.
Present yearly net savings ..... Approximate per cent return on investment .....
Brief description of how these savings were realized .....
.....

2. *Coaling Stations*

Number of stations electrically equipped to replace gas, steam or other drive .....

ANALYSES OF ORIGINAL RECOMMENDATIONS

No. stations where better service was a controlling factor.....
No. stations where decreased maint. was a controlling factor.....
No. stations where labor saving was a controlling factor.....
No. stations where fuel saving was a controlling factor.....
No. stations where saving in fixed chgs. was a controlling factor.....
Bearing in mind the reduction in labor, repairs, etc., please give the following for at least one installation.
Present yearly net savings ..... Approximate per cent return on investment .....
Brief description of how these savings were realized .....
.....

3. *Car and Locomotive Shops*

Number of shops electrically equipped to replace gas, steam or other drive .....
Number of motors installed ..... H.P.....
Number of engines replaced ..... H.P.....

ANALYSES OF ORIGINAL RECOMMENDATIONS

No. shops where better service was a controlling factor.....
No. shops where decreased maint. was a controlling factor.....
No. shops where labor saving was a controlling factor.....
No. shops where fuel saving was a controlling factor.....
No. shops where saving in fixed chgs. was a controlling factor.....
Bearing in mind the reduction in labor, repairs, etc., please give the following for at least one installation.
Present yearly net savings ..... Approximate per cent return on investment .....
Brief description of how these savings were realized .....
.....

4. *Turntables*

Number of turntables electrically equipped to replace other forms of drive .....

ANALYSES OF ORIGINAL RECOMMENDATIONS

No. turntables where better service was a controlling factor.....
No. turntables where decreased maint. was a controlling factor.....
No. turntables where labor saving was a controlling factor.....
No. turntables where fuel saving was a controlling factor.....
No. turntables where saving in fixed chgs. was a controlling factor.....
Bearing in mind the reduction in labor, repairs, etc., please give the following for at least one installation.
Present yearly net savings ..... Approximate per cent return on investment .....
Brief description of how these savings were brought about .....
.....

5. *Electric Arc Welding*

Number in service ..... D.C. ..... A.C. .....
Number of single operator sets ..... Number of multiple operator sets .....
Number of automatic arcs ..... Number of semi-automatic arcs .....
Number of Butt welders ..... Number of Spot welders .....
Number of electric rivet cutters .....
Bearing in mind the reduction in labor, better service, etc., give some typical savings effected by the use of the electric arc .....
.....
.....
.....

6. *Additional Apparatus*

If on your railroad economies have been made possible by other electrical applications than listed above, such as lighting, both indoor and outdoor, air-compressors, air tools, air hoists, cinder handling apparatus, and trucks and tractors, please give the data on at least one of these applications.

An Oil-Electric Locomotive

AN ELECTRIC locomotive, driven by a fuel-oil engine, the first of its kind built in America, has been built jointly by the General Electric Company and the Ingersoll-Rand Company. This has been especially designed for switching service and will be given its first practical test by the New York Central in its freight yards on the west side, New York City.

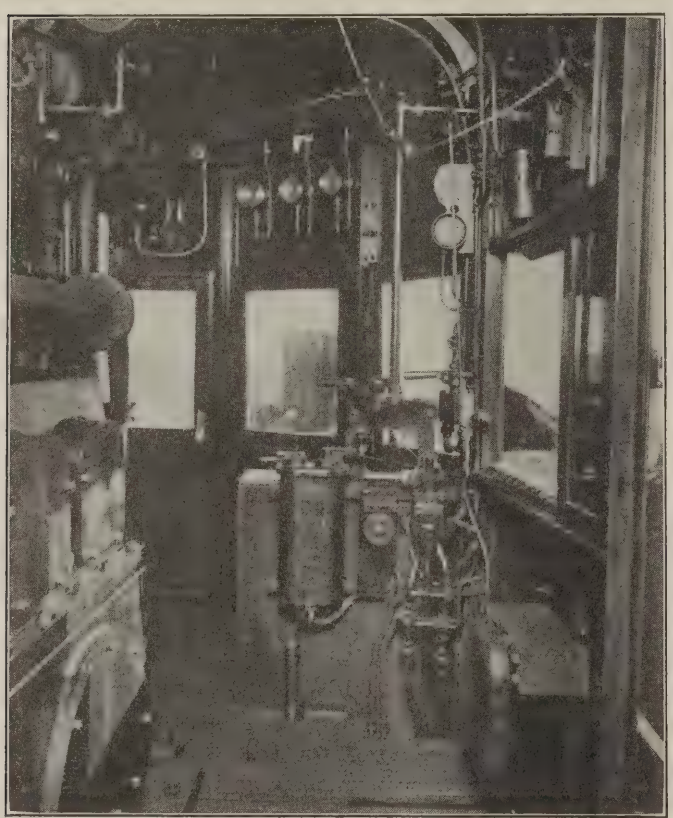
The power plant equipment consists of a 300-hp. oil engine, manufactured by the Ingersoll-Rand Company, directly connected to a 200-kw. General Electric generator. The motive power consists of four HM-840 General Electric motors, one of which is geared to each of the four axles. The unit has a total weight of 60 tons, all on the drivers.

During the last 15 years the General Electric Company has had considerable experience in the construction of self-propelled motor cars and locomotives using gasoline as fuel. About 90 equipments have been put into service during this period and most of them are still operating. In order to take advantage of a low-priced fuel in the internal combustion engine, an arrangement was made with the Ingersoll-Rand Company to build an engine designed for the use of fuel oil and having the characteristics of speed and weight that would be suitable for its use in a locomotive. The complete locomotive is, therefore, a combination of pieces of apparatus, each of which has been well tried out and whose combination

promises to result in a high degree of fuel economy. The locomotive has been in use in the yards of the Ingersoll-Rand factory at Phillipsburg, N. J., for about four months.

The six-cylinder engine is designed to burn fuel oil according to the principles of the well-known Price system of direct fuel injection. This system avoids the use of high pressure injection and also effects a reduction in weight, an improvement in mechanical efficiency and increased simplicity and reliability. The fuel is injected into the various cylinders through a distributor by means of a single acting plunger type pump. The lubricating system is of the continuous filtration type, by means of which the oil is returned from a crank case and passes through an oil filter before returning to the system again, thus insuring clean oil.

All parts of the cylinders, cylinder heads and combustion chambers are water cooled. The water from the water jackets passes to a radiator located on the roof and



Interior of the Cab, Showing the Throttle and Controller—the Oil Engine Is at the Left

a thermostat maintains an even temperature irrespective of weather conditions. Sufficient fuel can be carried for 48 hours' continuous switching service. The muffler for reducing the noise of the exhaust is also mounted on the roof.

The engine consumes about 0.43 lb. of fuel oil per brake horsepower. Owing to its high economy, it is free from smoke, which renders it particularly suitable for service in cities or in places where smoke is objectionable. As ordinarily used in switching service, the locomotive has consumed about 20 to 26 cents' worth of fuel oil per hour.

The unusual feature of the design of this locomotive is the use of a direct current generator supplying current to the motors without intervening accelerating resistances. This is accomplished by using a differential series field on the exciter, which automatically reduces the generator voltage with the increase in the amount of current drawn by the motors. The speed of the locomotive, therefore, automatically increases as the load is reduced, corresponding to the rise in impressed voltage. This control

Front End View of the Oil-Electric Locomotive Built Jointly by the General Electric Company and Ingersoll-Rand Company

completely eliminates the possibility of overloading the generator or motors or of stalling the engine.

The control is so arranged that the opening of the throttle by moving the control lever increases the engine speed and at the same time energizes the exciter field which in turn energizes the generator field. The generator current passes through differentially wound series field to the driving motors and being opposed to the separately excited field lowers the generator voltage in proportion to the load. As the locomotive accelerates, the current passing through the differential series field is gradually reduced, the generator voltage automatically increases and speeds up the locomotive. The main excitation of the exciter field is furnished by a storage battery which also supplies control current and locomotive lights.

Individual electric plants are not very widely used on farms in Great Britain, but are found to a considerable extent on large country estates and are becoming increasingly popular for use in small country bungalows. As a rule they could be arranged to furnish power for pumping or for other industrial purposes, but in practice are rarely so used. They are probably most popular in Scotland, where there are from 6,000 to 7,000 in use.

They are reported to be extensively used also in the Birmingham district and in goodly number in the Leeds, Sheffield, and Bradford districts—which would indicate that their use is more general in the Midlands than in any other parts of England. It is reported that in the Plymouth district they are quite common on large country estates and farms, from 4,000 to 5,000 having been sold in the County of Devon. They are not generally used in Ireland, and the few that are in operation are employed for large country homes and hotels.

Railroad Yard Lighting

A Discussion of the Various Methods of Using Floodlighting Projectors With Advantages of Each

By W. C. Gilman
Illumination Dept. General Electric Co.

THE subject of railroad yard lighting, although one of vital interest to the railroads, does not seem to have given cause to very much research or study of the illumination principles involved by the people responsible for the present installations.

The movement of freight cars is a continuous performance, and anything which tends to expedite this movement with a decreased breakage and theft loss and with less chance of danger to the train operators is consequently of greatest importance not only to the railroads but also to our whole economic life. Actual statistics collected by some of our larger railroad systems prove by figures the many advantages of proper lighting of the railroad yard.

The committee on illumination of the Association of Railway Electrical Engineers report the following advantages of yard lighting:

"(a) Speeding up of cars handled in the yard at night time.

"(b) Reduction in cars damaged by rough handling and collision in the classification yard with consequent reduction in claims, delay in delivery of goods, loss of service of damaged cars, etc.

"(c) Reduction in losses due to pilfering on account of more effective policing possible with a well-illuminated yard.

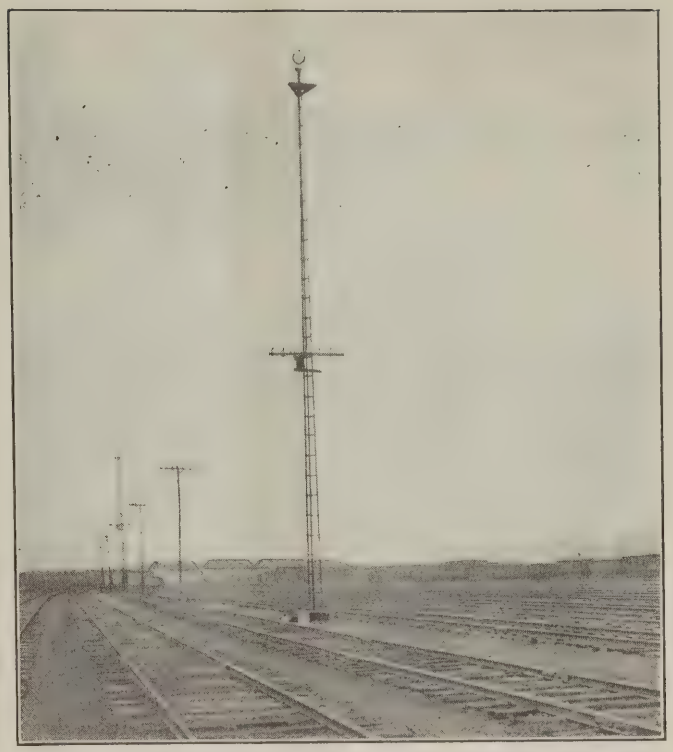
"(d) Improved working conditions and increased safety for employees working in the yard."

That these benefits are appreciable is evidenced by the fact that certain railroads during the past year have authorized relatively large expenditures for improved yard illumination.

In order to realize fully the advantages of proper lighting in a yard it is well to analyze the operations which take place there. We will examine a classification yard of the hump type, since these are by far in the majority.

A train of mixed freight pulls into the receiving yard and its road locomotive uncouples and pulls away from it. A switching list is then made out for this train, assigning each car to a particular track in the classification yard depending on its ultimate destination.

A switching locomotive then hooks on to the rear end of this train and pushes it up to the hump. As each car, or more exactly each cut of cars, consisting of perhaps one to four cars of the train, comes on to the hump, it is uncoupled and by force of gravity runs down into the classification yard. The car is consigned to its proper track by the operator in the signal house, where switching is done automatically, or by switchmen in the yard where the manual system is employed. As each cut passes over the hump a car rider mounts it and applies the hand brakes so that the cut is brought to a standstill in its proper place in the classification yard. When the proper number of cars for a train are in position on any one track in this yard, a road locomotive picks them up and they go on their way again.



Method of Mounting Projectors on the Philadelphia & Reading Railroad in the Freight Yard at Rutherford, Pa.

The speed of car movement in the yard is greatly increased by an effective lighting equipment. Operators are able to do their work efficiently instead of having to grope around in an uncertain manner in the dark. Particularly is this true of the switchmen in a manually operated system. Each switchman has switches to throw in a short space of time for each cut, and it is imperative that he be able to see what is going on around him as well as to see the switches and tracks in his immediate vicinity. The car rider riding his cut of cars from the hump must be enabled to distinguish at relatively long distances at any point in the yard the cars in the yard ahead of him, and thus be able to control the speed of the cars on which he is riding, so as to prevent damage due to collision on the one hand, or stopping short and thus failing to couple on the other.

It is also desirable to have the throat of the yard and ladder tracks visible from the hump so as to observe when cars have cleared the fouling points at switches, etc. This is particularly true in yards not equipped with a modern interlocking plant for operating switches from a centralized point.

As soon as each car rider has delivered his cut to its proper place, he dismounts and proceeds on foot or by conveyance from some central point to the signal house and takes his turn on another cut. It is most important for the safety of the lives of these men that there be sufficient illumination in the yard to enable them to discern cars coming down the tracks toward them as well as to see between the cars. The cars slide down from the hump silently, and unless there is good lighting in the yard it is obvious that this is a most dangerous hazard.

It is an established fact that the proper lighting of any section decreases almost immediately the amount of theft and crime in that section. Particularly is this true with respect to the theft of material and freight from yards. One particular railroad which has recently put in lighting in several of its yards reports a 50 per cent decrease in theft since the installations were made.

The lighting of railroad yards has employed up to this time two distinct types of units—(1) Pendent units. (2) Floodlighting projectors.

It will not be necessary in this discussion to consider the pendent type of unit since opinion is almost universal that the most effective results are to be obtained by the use of floodlighting projectors.

From the standpoint of light projection there are two general arrangements of floodlighting projectors in a railroad yard.

(1) Light projected in direction of traffic.

intervals of from 1,000 to 3,000 feet in the yard.

Fig. 1 shows a typical general layout of a system of this kind when the light is projected in both directions in the yard parallel to the tracks. The floodlights on any one tower are, as a rule, adjusted to cover the 500 to 1,500 feet of the yard nearest the tower. The length of yard which is assigned to be covered by one bank of projectors determines the spacing of the towers, which is twice the above distance, or from 1,000 to 3,000 feet.

In many cases light is projected in both directions from the same tower. The number of floodlights per tower is determined by the width of the yard and also varies, of course, with local conditions, smoke, fog, shape of yard, available space, etc.

The group system of lighting a yard does not give a very uniform distribution of light, due to the wide spacing of the units. This wide spacing does not give good results when smoke or fog are present in the yard, since

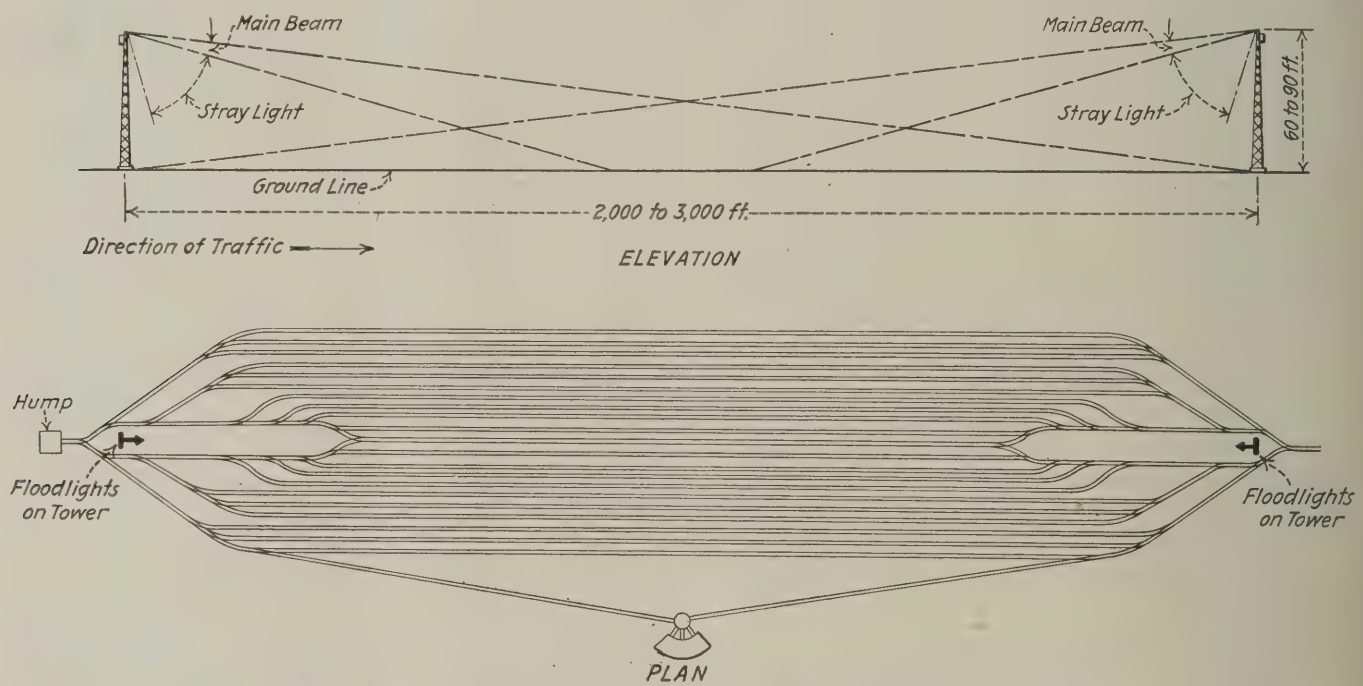


Fig. 1—Scheme of Floodlighting by the Group Method with Two Way Projection

(2) Light projected against the direction of traffic.

Where the light from the projector is directed with the direction of traffic, any possibility of dangerous glare is eliminated, since the direction of vision is always away from the projector, at least as far as the operators on moving cars are concerned.

In the second method, where the light is directed against the direction of traffic, the great advantage of specular reflection from the rails and consequent silhouette effect is obtained. This effect increases to a marked degree the apparent illumination in a yard. However, this advantage is to a considerable extent offset by the fact that there is the danger of blinding the operators in the yard by glare.

The lighting in railroad yards may be classified in two divisions, depending on the manner in which the units are arranged: (1) Group system. (2) Distributed system.

Group System—Two-Way Projection of Light

The group method employs floodlighting projectors in banks of three to sixteen mounted on towers spaced at

light will not penetrate these fogs for any great distance. There is also the possibility of dangerous glare.

The advantages of the group system, two-way projection of light, are economy of installation and maintenance and silhouette effect. Some of the disadvantages are non-uniform distribution of light, inefficiency in smoke or fog and danger from glare.

One-Way Projection of Light

This system of lighting is shown in detail in Fig. 2. By having the projection of light in one direction alone, the advantages of the group system are obtained without the disadvantage of glare, characteristic of the two-way projection. The advantages of this one-way projection of light are economy of installation and maintenance and no glare, while the disadvantages are found in the loss of the silhouette effect, in the non-uniform distribution of light and the inefficiency in smoke or fog.

Distributed System—Light Projected with Traffic

In this method of yard lighting single floodlights or, at most, two floodlights, are mounted on poles or on towers

spaced roughly from 250 to 500 feet and with the beam from the projectors directed parallel to the tracks in the same direction as the direction of traffic.

With a system of this kind there is never any danger of glare, for the direction of movement of cars, which is the direction in which one looks, is always away from the projector. Since the units are distributed throughout the yard, it is possible to obtain a much more uniform distribution of light. In addition to this, it is possible to use a stippled glass lens which gives an even wider distribution of light and reduces the intrinsic brightness of the source. The advantages of this type of distributed system are the uniform distribution of light, effectiveness in smoke or fog and the absence of glare. The disadvantages arise from higher installation and maintenance costs and the lack of silhouette effect.

Distributed System—Light Projected Against Traffic

This method of lighting gives a more uniform distribution of light than the group method, and from a glare standpoint is probably less objectionable than that method with two-way projection of light, since there are never more than two floodlights at any one location. Its advantages are found in uniform distribution of light, effectiveness in smoke or fog and in the silhouette effect which is obtained. The disadvantages consist of higher installation and maintenance cost and possible glare.

Distributed System—Light Projected Diagonally Across Tracks

Fig. 3 shows this method of lighting with the beam from the projector directed diagonally across the tracks against the direction of traffic. The projectors, singly or in pairs, are, as a rule, mounted on 75 ft. poles or towers, spaced from 200 to 500 feet. This system gives the silhouette effect and effect of specular reflection from the rails and also tends to provide uniform illumination throughout the yard. The advantages of this method are uniform distribution of light, silhouette effect and effectiveness in smoke or fog, while the principal disadvantage is higher installation and maintenance cost.

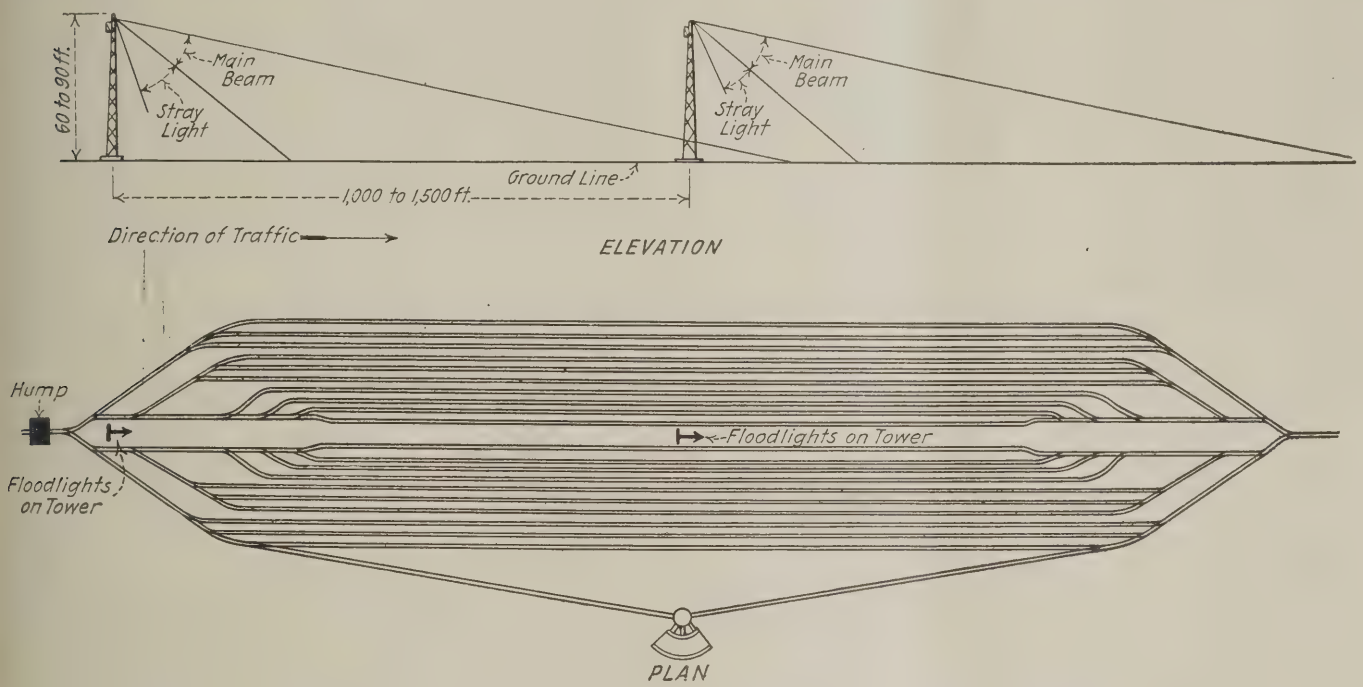


Fig. 2—Scheme of Flood Lighting Railroad Yards by the Group Method—One Way Projection of Light

Towers

The construction of a typical wood floodlighting tower suitable for railroad service is shown in Fig. 4, while Fig. 5 shows sketches of the steel type of tower. The steel construction allows a smaller base, which feature is very important in the railroad yard where ground space is valuable. It is probably a more permanent structure when properly maintained by periodical painting. At the lower mounting heights the wood tower is in most cases cheaper, but this advantage disappears as the height is increased.

The question of the proper mounting height of projectors is a most important one. It is sometimes difficult to convince a man that the tower height should be 75 feet

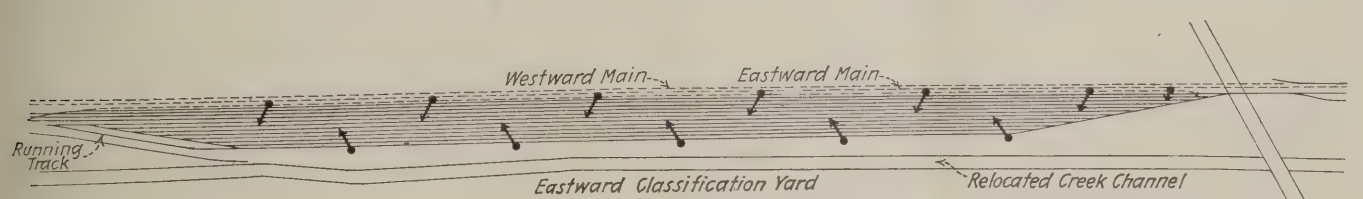


Fig. 3—Two Type L-12 Floodlights on 75 ft. Steel Towers at Each Location Indicated—1000 Watt, 110 Volt Lamps Are Used with Stippled Lens

instead of 60 feet, and especially is this difficult when he learns that the cost of the 75-foot tower is very much more expensive. The higher mounting height is necessitated in order to minimize as much as possible dangerous glare effects, to give a more uniform distribution of light and to eliminate objectionable shadows.

In making recommendations for towers, 75 feet above the rails should be considered as the minimum projector mounting height.

Cost of Wood Towers

Following are approximate figures covering cost of western red cedar poles suitable for tower construction. Attention is called to the fact that two such poles are necessary for the construction of a tower.

To these figures must be added the cost of the wood platform at the top and attendant construction such as is shown in Fig. 4.

	EACH
10" top 60' poles	$49.10
70' "	119.80
80' "	162.80
90' "	200.00
100' "	239.00

	EACH
8" top 60' poles	$32.90
70' "	49.10
80' "	76.10
90' "	119.80
100' "	162.80

Cost of Steel Towers

The cost of steel towers varies considerably with the type of tower which is used. The following figures apply

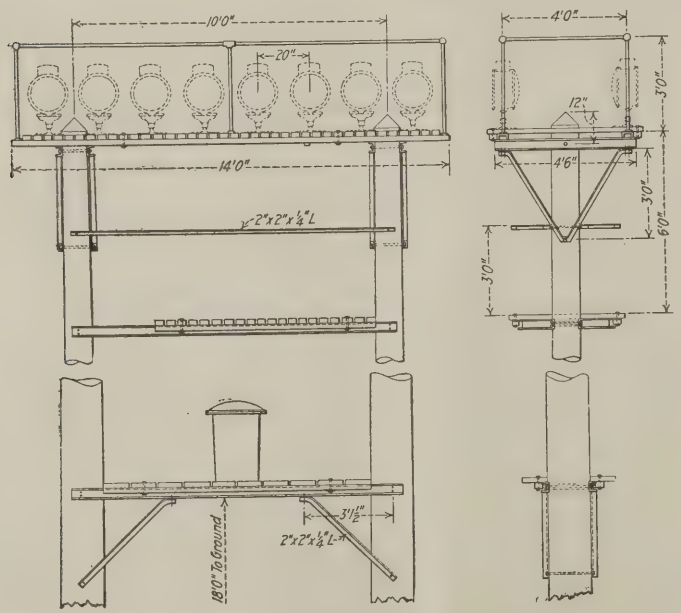


Fig. 4—Wood Pole Tower for Floodlights in Railroad Yards

to the type of tower which is shown in Fig. 6; they should be considered as merely a rough estimate.

70 ft. tower with double platform so that the lights may be faced in two directions, complete with all necessary bolts for field erection, to carry from 4 to 12 floodlights $300.00

75 ft. tower with the top to carry two floodlights, with single platform, complete as above $227.00

These towers at the foregoing prices would be shipped knocked down for field assembly; consequently, to these costs should be added the cost of assembly and cost of concrete base in estimating the total cost of the complete tower in position.

Total Cost of Steel Towers Installed

Material	
Tower assembled	$350.00
Foundation	50.00
Labor	
Erecting tower	150.00
Building Foundation	150.00
	$700.00

Floodlighting Projector for Railroad Service

A floodlighting projector for railroad service in a yard where the sulphuric acid gases in the smoke are ever

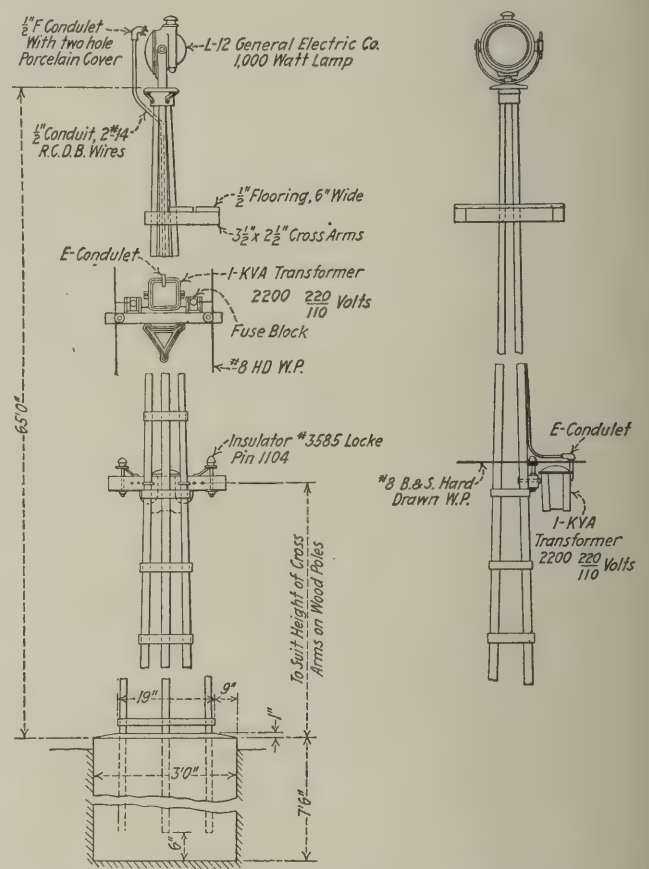


Fig. 5—Some Details of a 65 ft. Steel Tower for Use in Yard Lighting

present must be constructed of a material which will withstand attack from these gases. The units are at all times exposed to the weather and should be weatherproof and of a material which does not rust. These requirements seem to indicate that a cast aluminum alloy construction would be most acceptable.

The 1,000 watt, 110 volt mazda C multiple lamp seems to be the most universal size in use for this service, but now that the 1,500 watt lamp is available, consideration should be given to a projector which can handle this size lamp when planning an installation. It is most important that once the beam of the projector is directed to a certain portion of the yard it remains there; consequently, it is imperative that an electrician or maintenance man be able to relamp or clean the reflector without changing the projector direction. Since the platform for the maintenance man to stand on is in many cases at the rear of the projectors, this result may be accomplished by having

a projector with a hinged back door. With this type of construction a workman may perform his duties without having to place himself in a precarious position on the platform and at the same time without danger of moving the projector.

The determining factor on the amount of light in the yard is the value of beam lumens from the projector, and consequently careful consideration should be given to the efficiency of the unit. Since in many cases the throw is of the order of one thousand feet or more, the unit must have a high value of central beam candle-power. Towers and space in the railroad yard are very expensive, and

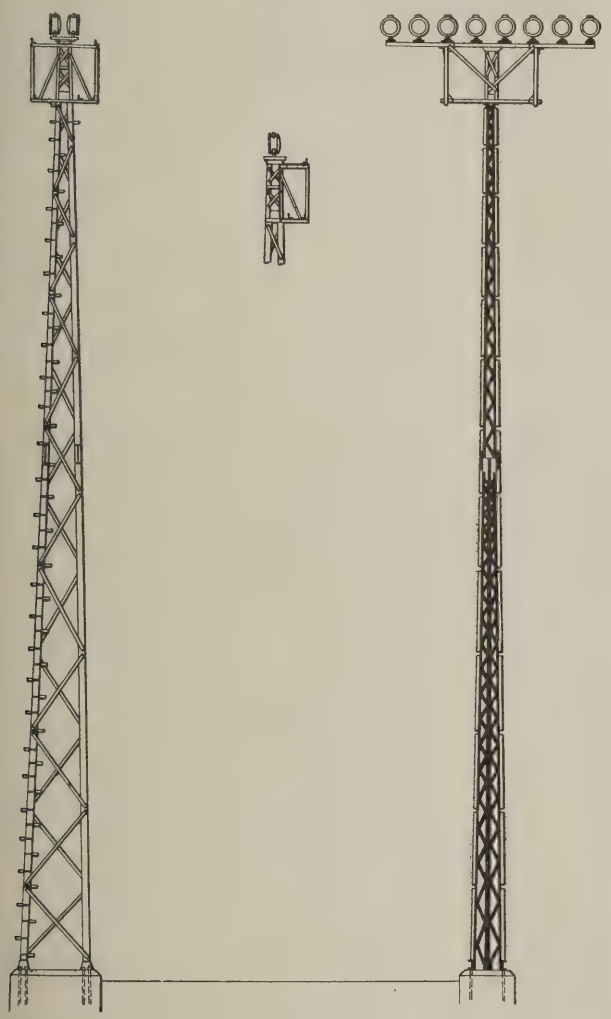


Fig. 6—Steel Tower for Floodlights in Railroad Yards

anything that can be done to reduce the number of projectors necessary to light a given area is a most important consideration.

Distribution System

The distribution of power for the floodlights in a yard can always be determined by a study of local conditions. As a rule a 2,300-volt line is available, and this voltage can be stepped down to 110 volts by means of a small transformer on the towers. There are without doubt some cases where it would be desirable to use a series system of distribution with a series primary 110-volt secondary transformer on each tower. This latter system would be particularly advantageous where there is an already existing series circuit in the yard.

Recommendations

In making recommendations for the lighting of a railroad yard, it should be borne in mind that there is no royal rule that is applicable to all cases any more than there is such a rule for the solution of street lighting problems. However, there are a few rough rules to serve as a guide in the layout of a system.

Group Method

Assume one projector for every four tracks for every thousand feet of yard. This will give roughly the number of projectors necessary. They may be arranged in banks all facing in one direction or facing in both directions as appears advisable.

Distributed Method

Assume one projector per 200 feet of yard for every 200 feet width of yard. The projectors may be arranged with the light directed against traffic, with traffic, or diagonally across the tracks as may be thought the best method.

If the above rules are followed there will be from .02 to .025 watts per square foot in the yard. With the most efficient lighting projector, these values of watts per square foot will give an average intensity of illumination throughout the yard of from .125 to .15 foot candles, neglecting depreciation. In these calculations the beam lumens only are considered as being valuable in providing light. Any stray light is local and would not be of a useful nature.

Nickel anodes used in nickel plating have formed the subject of a recent investigation. The purpose was to determine the relative behavior of different forms of nickel, such as electrolytic, rolled, and cast nickel, in the solutions used for electroplating. The experiments showed that the addition of a chloride to the solution caused all types of anodes to dissolve with a high efficiency. The chief difference in the behavior of the different types of anodes was in the uniformity with which they dissolved.

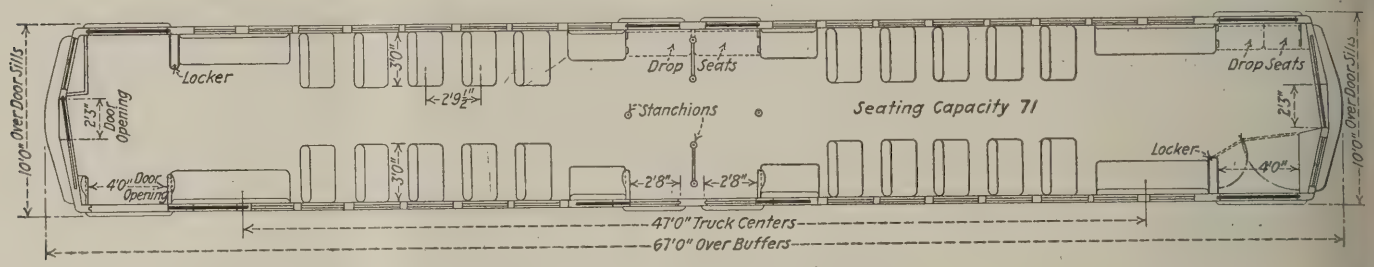
Ewing Galloway

Railway Station at Sao Paulo, Brazil

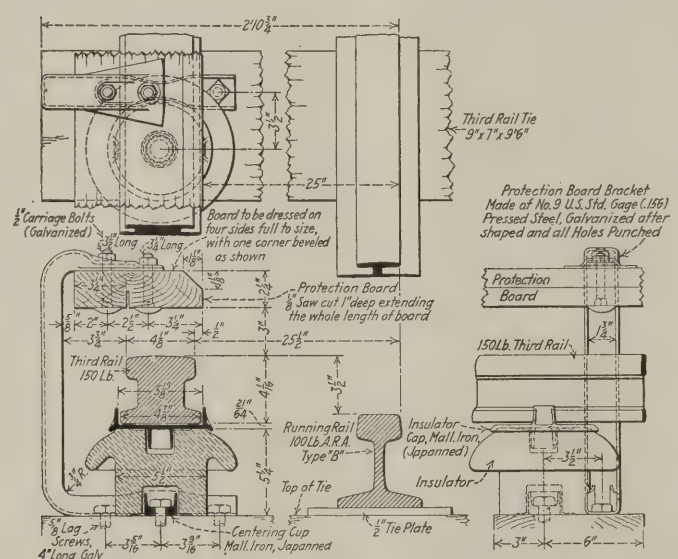
Plans for the Baltimore & Ohio Electrification on Staten Island

THE Staten Island Rapid Transit Railway Company will electrify its passenger service on the East Shore division and the Perth Amboy division as rapidly as plans can be developed and the work executed. This includes lines between St. George, South Beach and Tottenville, Staten Island. The total track mileage which will be electrified at this time is approximately 40 miles.

The 600-volt direct-current third-rail system will be employed. Preliminary plans include an over-running protective type of third-rail construction with 150-pound third-rail of special high conductivity steel on main lines.



Floor Plan of One of the Multiple Unit Cars


Third Rail Tie
Protection Board Bracket
Protection Board
Board to be dressed on four sides full to size, with one corner beveled as shown
Protection Board
150 Lb. Third Rail
Third Rail 150 Lb
Running Rail 100 Lb. A.R.A. Type "B"
Insulator Cap, Mall. Iron, (Japanned)
Insulator
Top of Tie
Centering Cup Mall. Iron, Japanned

The Over-Running, Protected Type of Third-Rail to Be Used

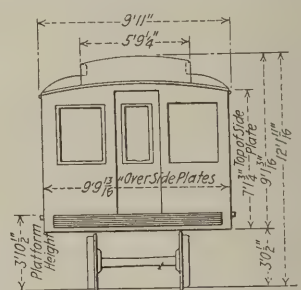
It is probable that the electric energy for multiple-unit operation will be purchased from the Staten Island Edison Corporation. Tentative plans cover 33,000-volt, three-phase, 60-cycle power supply to be delivered to the railway company's substations where the high potential alternating current will be transformed and converted for feeding the 600-volt direct-current third-rail. Several of the substations will be of the automatic or remote control type. The substation layout is designed to provide power facilities for a considerable increase over the present requirements.

The multiple unit car which will probably be adopted will be of all-steel construction approximately 67 feet overall in length and of modern design throughout. The car will seat 71 passengers. There will be double doors at the center and a wide door in the side at each end of the car with end doors to permit passing between cars. All side doors will be electro-pneumatically operated. Each car will be equipped with two motors, one to be located on each truck and double-end multiple unit control will be provided which will permit the operation of trains of from one to ten cars. Initially the maximum train will be made up of six or seven cars.

Previous to electrification new 100-lb. running rail will be laid in place of the 75 and 80-lb. rail now used on a large part of these lines. Also the section between Prince's Bay and Pleasant Plains which is now single track will be double tracked and grade crossings eliminated on this section.

The change to electric power will necessitate the installation of practically an entire new signal system. The direct current signals now installed will be superseded by a modern alternating current signal system.

Electrification will result in a substantial increase in schedule speed of trains compared to the present steam service and will afford high class rapid transit service to the rapidly growing residential districts of Staten Island. The electrification work is being handled under the direction of J. H. Davis, electrical engineer of the Baltimore & Ohio.



End Elevation of One of the Multiple Unit Cars

During the last two years no less than twenty electric farm-lighting plants have been sold in the island Grand Canary, bringing the total number for that island up to about thirty, and for the Canary Islands up to from fifty to sixty. Of the nineteen plants, concerning which detailed information is available, seventeen are of 32 volts, one of 65 volts, and one of 110 volts; twelve are from 1 to 4 kilowatts, and the remainder are of 600 and 850 watts capacity. These types will probably continue to be the popular ones, although small villages are expected to purchase such sizes as may be required. Up to the present, American makes of farm lighting plants prevail. Dealers in electrical goods are best equipped to sell, install, and repair lighting plants; but the hardware dealers are also interested.

Steam Locomotive Hauling Electric as a Demonstration of Regenerative Braking

Electric Traction Exhibit Held at Erie, Pa.

Demonstration Includes a 3,000-Volt Direct Current Multiple Unit Train for Suburban Service

ELECTRIC locomotives, a steam locomotive, a 3,000-volt multiple unit train, a laced type overhead trolley, a hornless pantograph and the otheograph were included in exhibits and tests held by the General Electric Company at Erie, Pa., on May 19.

The electric locomotives shown included two of those just completed for the Mexican Railway Co., Ltd., described in the December, 1923, issue of the *Railway Electrical Engineer*, page 403, and a Chicago, Milwaukee & St. Paul gearless passenger locomotive. The C. M. & St. P. locomotive which was placed in service on the Cascade division early in 1920 was described in the March, 1920, issue of the *Railway Electrical Engineer*, page 109. It is now being taken through the East by the passenger department of the railroad. From Erie the locomotive and the coach which accompanies it will be taken to the following cities in New York state: Buffalo, Syracuse, Utica, Schenectady, Troy and Albany; it will be on exhibit during the American Railway Association Convention at Atlantic City, N. J., June 11 to 18.

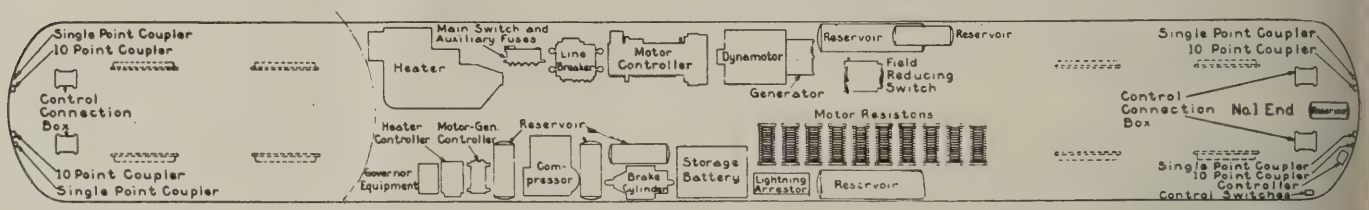
The Multiple Unit Train

The multiple unit train consists of a motor car and a trailer coupled in the usual fashion with automatic couplers. The car which has been used for the installation of the electrical equipment was purchased from the Michigan Railway Company and had previously been in operation for about two years on 2400-volt direct current between Kalamazoo and Grand Rapids, Michigan. The 2400 volts was later changed to 1200 volts because of third rail difficulties. The body is 66 ft. 10 in. in length over the vesti-

The New 3000-Volt Direct Current Multiple Unit Train

bules and contains parlor, baggage and smoking compartments, as well as main passenger section. The equipment installed includes four GE-280-1500/3000 volt railway motors, type PC control, an electric hot air heating system, low-voltage multiple lighting and a complete equipment of combined straight and automatic air brakes.

The motors are geared in the usual manner to the four axles of the car and arranged for operation in full series or series-parallel. Each motor has an hourly rating of



Floor Plan of the 3000-Volt Multiple Unit Car Showing Location of Equipment

200 hp. and weighs complete with gear, pinion and gear case approximately 6,875 lb. The motor is practically the same mechanically as the 1500-volt motors recently built for the Paris-Orleans Railway, except that insulation has been added to take care of the higher trolley voltage. Minor changes were also necessary in windings and commutator. The motor is of the standard ventilated design. The gear reduction is 70/21 giving a ratio of 3.33 and a maximum emergency operating speed with 36 in. wheels of 60 miles an hour.

The motor capacity is sufficient to handle without overheating a 40-ton trailing coach, and at a somewhat reduced schedule, two trailing coaches. For demonstration purposes, the trailer has been equipped with control coup-

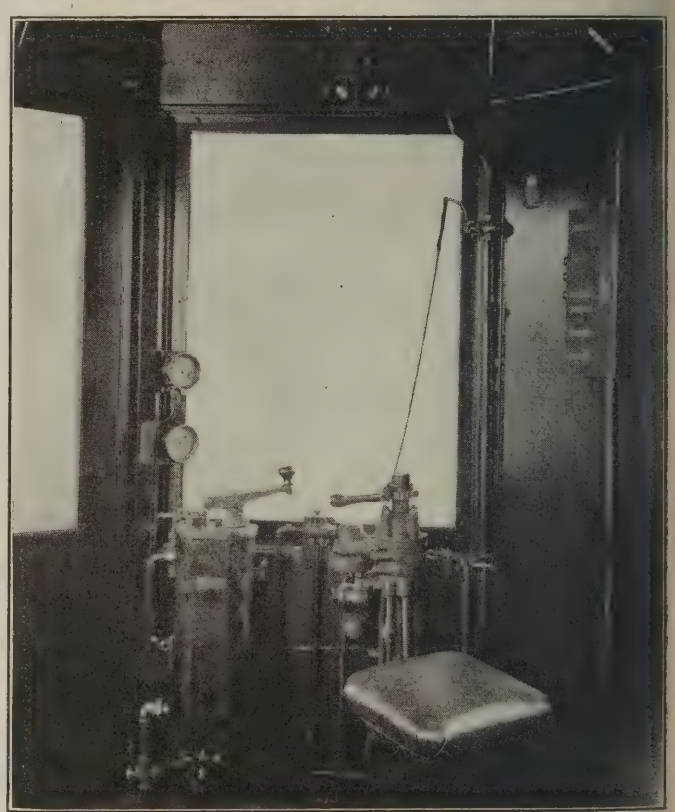
Device Used to Record the Rise of the Contact Wire with Relation to the Upper Wires Caused by the Passing of One or More Pantographs

lers and cables and a master controller at one end. The train can, therefore, be handled from the front end of the motor car or in the reverse direction from the control trailer.

The control is designated as PC-104 electro-pneumatic type and consists of a cam operated switch group. In general the design is similar to the 1500-volt control used for the Paris-Orleans motor cars with provision for higher voltage. The low voltage for control and lighting is obtained from a small 65-volt generator having the armature carried on the shaft extension of a 1500/3000 volt dynamotor. The dynamotor winding is used to operate the CP-30 air compressor at 1500 volts. A 28-cell storage battery is floated across the 65-volt generator which operates the lights and control apparatus when the set is shut down.

A feature of the control is a line breaker consisting of high speed contactors connected in series for interrupting the 3000-volt circuit. When the master controller is thrown to the off position, the motor current is broken by the line breaker, which reduces the duty on the other equipment. The control is arranged for seven steps full series and six steps series-parallel, including the tapped field connection on the last step.

The heater equipment consists of a 30 kw. and a 10 kw. grid taking current from the 3000-volt bus line with suitable control. These heating elements are enclosed in an insulated box underneath the car. The hot air is carried to various parts of the car through a duct by a motor



Control Apparatus in Cab of Motor Car

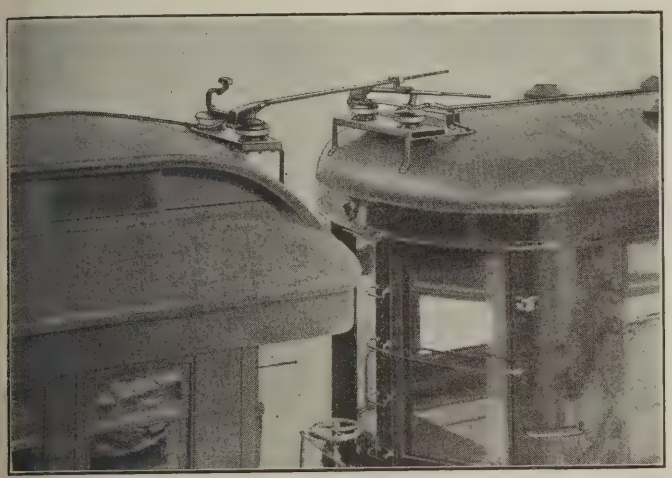
driven blower. Similar equipment is also installed for heating the trailer coach.

The connection between the 3000-volt heater bus on the motor car and the trailer is made by a simple device called the type SZ-14-A coupler. A swinging arm with insulating support resembling a miniature trolley and base is mounted on each car and the connection is made by placing the arm of one car under a hook on the other. The

coupler is manipulated from the ground by a switch hook. Current is collected from the overhead trolley by a single type S-501 slider pantograph.

Current Collection Tests

In the early part of 1923, the General Electric Company was asked to supply certain definite information regarding the limits of current collection from an overhead trolley wire at different voltages. This information was requested in connection with the proposed 1500-volt electrification of the Cleveland Union Terminals, where it is anticipated that unusually severe conditions will exist. It was found that very little authentic information was available, and it was therefore decided to make a complete investigation of the problem.



Device Used to Connect 3000-Volt Heater Circuit on Trailer to Power Circuit on Motor Car

The present laced type construction used on the four mile experimental track was finally selected as the most satisfactory design for collecting heavy current at any speed and also most suitable for conducting current to the contact wire.

The test train used to demonstrate current collection consists of a 110-ton gearless locomotive arranged for operation on either 750 or 1500 volts followed by a gondola in which are installed sufficient iron grid rheostats to consume the current required for the test. Sections of the rheostats can be inserted or removed by remote controlled contactors to give whatever current may be called for.

Another problem which arose in this connection was the detail of construction upon approaching and leaving a low overhead bridge. Tests are therefore now being made to determine the most satisfactory slope of the contact wires upon approaching and leaving points of minimum clearance. The temporary equipment used for these tests includes a skeleton bridge from which conductors are supported by means of adjustable supports, so that tests could be made using a slope of the contact wire, varying from ½ to 1½ per cent. The height of the contact wire varies from 18 ft. 6 in. to 22 ft. above the rail. A device is also used to indicate accurately the amount of vertical movement of the contact wires upon the passing of each pantograph. Accurate information is thus being secured to solve the engineering problem of collecting heavy currents from a moving pantograph at various speeds and under all conditions.

The Otheograph

The otheograph is a device designed to record the action on the rails of each separate wheel of a locomotive or motor car. It shows by a graphic record the amplitude and characteristic of both the vertical and transverse thrust of the wheels on each tie. The vertical deflection is transmitted through heavy springs underneath the rail and the transverse deflection through similar springs set vertically and bearing against the head of the rail. The deflection of these springs on the passage of a locomotive is recorded through a lever arm with a pointer at the end which traces a record on paper wrapped around a rotating cylinder similar to an engine indicator.

The otheograph ties may be installed in place of the regular ties on the track, either singly or in a grouping of several, and on curves or tangent tracks. The installation on the Erie test tracks comprises 25 of these ties grouped together covering a distance of fifty feet in tangent track. The revolving mechanism provides for moving all of the recording cylinders on each side of the track simultaneously allowing as many records to be taken of each side of the locomotive as the number of the ties that are grouped together. The movement of the operating mechanism for the recording cylinders is independent of the speed of the locomotive. The operating mechanism is driven by a constant speed motor with suitable gear reduction in order that the distances between the peaks on the curves are proportional to the actual distance between the wheels on the various locomotives.

Chain Block and Gallows Used to Adjust Grade of Trolley Ahead of the Structure Shown at the Rear, Which Represents Overhead Bridge

Each record taken shows all the wheels of the locomotive and is so made that the pressure and lateral movement of the leading wheel is shown at the left end. Each recording head indicates the vertical and lateral deflection of the rail as the successive wheels pass over the tie. The record is not necessarily limited to one locomotive only, as, by moving the paper slowly, the record of all the wheels of an entire train might be taken.

Particular attention has been given in the installation of the otheograph test tracks at Erie in an effort to ob-

tain the same type of roadbed as the rest of the track. Each of the otheograph ties is located immediately over a wooden tie with the same supporting ballast as elsewhere. Between the otheograph tie and the wooden tie is a thin wooden stringer to retain the alignment but with no appreciable vertical stiffness. The action of the locomotive running over these two would seem to indicate that no unusual track condition is imposed.

In cases when wheels are close together, it is probable that the wheel which has just passed an indicating point on the otheograph is still having some effect on that point as the following wheel passes the point, due to stiffness of the rail. The otheograph does, however, give an accurate record of the effect of a locomotive on the track. At present the results obtained are relative only, but a method has been devised for the purpose of applying a scale to the otheograph record so that it will measure the forces on the rail in pounds.

Locomotive Tests

Speed tests of the New York Central Mikado and the Chicago, Milwaukee & St. Paul electric locomotives were made by running the locomotives at various speeds along the test track over the otheograph. The Mikado was run at speeds up to 63 miles an hour and the electric at speeds up to 65 miles an hour.

The regeneration test consisted of pushing the electric with the steam locomotive and allowing the electric to return power to the trolley. This effectively demonstrates regenerative braking as it is evident that the steam locomotive is working under conditions of heavy load and in spite of the tractive effort applied to the rail by the steam locomotive the speed is held constant by the electric.

Grinding and Turning of Commutators*

While sandpapering offers a satisfactory method of resurfacing a commutator which is dirty or on which the mica is just beginning to get high and hand stoning will remove considerable high mica and even small flat spots, the only satisfactory methods of resurfacing a commutator which is badly out of true or on which the high mica or flat spots are bad enough to cause vibration of a hand stone, are grinding or turning with tools having a rigid support. All cases of eccentricity come under the latter head for no hand method of finishing can eliminate eccentricity in a commutator.

Before undertaking to grind or turn a commutator examine it carefully and make sure that it is tight. This should be done just after stopping the machine, while it is still hot, as the bars are most likely to be loose at such a time. Due to the seasoning of the insulation, most commutators need to be tightened after six to nine months' service and again after eighteen months to two years. Thereafter they should remain tight indefinitely.

The commutator may be trued with the armature in its own bearings or the armature may be removed and placed in a lathe or a machine designed especially for this purpose.

When turning a commutator without removing from the machine the armature may be driven at the proper cutting speed by a belt from a separate motor or the machine may itself be operated as a motor at a reduced speed. This may be done by inserting a high resistance in series with the armature so as to reduce the voltage at the terminals of the machine. If this method is used, it is necessary to insulate the tool post carefully from the rest of the machine and to see that all parts of the machine are carefully protected from copper chips. When turning the commutator in its own bearings it is also very important to see that the turning tool or grinder has a substantial support. Where a turning tool is used, it is better to build up a support from the base of the machine rather than to attach the support to the brush holder rigging.

When trueing the commutator in a lathe, the armature may be supported on the lathe centers or on sleeve bearings. The former is simpler but the latter has some advantage in point of accuracy. In case the armature has an abnormally long shaft, steady rests should be used to void the vibration of the shaft while turning.

The choice between the above methods of trueing, whether in its own frame or in a lathe, is largely determined by the size of the armature and the facilities for handling it. Armatures are generally removed to a lathe for turning unless too large. In grinding, there are some advantages in leaving the armature in its own bearings and running it near the normal operating speed of the machine. This eliminates the distorting effects of vibration and centrifugal force at the high speeds of operation. A commutator cannot be turned under these conditions, however, as the surface speed is too high. Furthermore, a lathe is usually designed to give the cutting tool a more rigid support than any which can be rigged up on the base of a machine, so if the commutator is to be turned, it is advisable to remove the armature to a lathe wherever this is possible.

Before starting to turn or grind a commutator the windings of the armature, adjacent to the commutator, should be wrapped in canvas or oilcloth to protect them from copper chips and dust. When the armature is to be ground at normal speed in its own bearings it may not be feasible to do this but the armature should be so protected whenever possible and always when it is to be turned; otherwise, chips of considerable size are practically certain to lodge in the windings and shorts are likely to result.

In grinding there are two general methods. One a stationary stone, the other a revolving wheel of abrasive material.

When grinding with a stationary stone a smooth, fine-grain sand stone should be used, the same as is used for hand stoning. This must be rigidly clamped in a holder and provided with a substantial support so there may be no chance of the stone digging into the commutator. Some experimenting may be necessary to determine the best cutting speed. Beyond a certain speed a stationary stone will not cut smoothly and it is seldom possible to grind a commutator at full speed by this method. The best cutting speed will probably be found around 1000 to 1500 F. P. M.

The rotating abrasive wheel is preferable to the stationary stone as it is not liable to chatter or dig into the commutator. A medium soft wheel should be used as the face will not fill up with copper as readily as that of a hard wheel. Use a light cut to prevent wear of the wheel giving the commutator a conical form. A heavy cut will also tend to reproduce any eccentricity of the commutator due to unavoidable spring in the supporting rigging.

* Abstract of a bulletin published by the National Carbon Co., Inc.

Where a commutator is badly out of true it may be necessary to take a large number of light cuts, but this is the only way it can be brought back to proper shape. Machines for this purpose are available, designed for attaching in a substantial manner to the brush holder rigging. Where a home made device is prepared this question of rigid support must be given careful consideration. If grinding is done with the armature in its own bearings, build up the support from the frame of the machine rather than attach it to the brush holder rigging to secure a more substantial support. Speed the cutting wheel at the rate recommended by the manufacturer of wheel used. Commutator speed will be determined by conditions. If a commutator that is badly out of true is to be finished entirely by grinding, it will be well to remove most of the eccentricity with the commutator revolving at a moderate speed. This will avoid excessive wear of the grinding wheel. After the commutator is approximately true it may be speeded up to its normal speed so that any distortion which takes place at such speeds will be eliminated. Final surface may be obtained by the use of a very fine abrasive wheel or fine grain sand paper. Some manufacturers put the final surface on their commutators with a hand stone. Whatever method is used, care should be taken to eliminate all scratches, especially those in a diagonal direction on the commutator surface and to bring the surface to as near a polished condition as is possible.

In turning a commutator with a steel tool use what is known as a "diamond-point" tool or one with a fairly sharp point. The point of the tool should be rounded sufficiently that the cuts will overlap and not cut a thread on the commutator surface. For the same reason it is necessary to use a fine feed. Use a light cut, taking several cuts, if necessary, to remove bad flat spots or a considerable degree of eccentricity, to avoid springing of the tool support, as mentioned under grinding. Furthermore, in turning a commutator with a heavy cut, the tool has a tendency to twist the segments, thus cutting deeper at one edge than at the other. This difference may be slight but less than .001-in. variation in the commutator surface is sufficient to break contact with the brush face, causing the current to jump across that point in the form of a minute arc and cause burning of the commutator surface. The surface speed must be lower in turning than in grinding. In general, a surface speed of 500 to 600 F. P. M. should not be exceeded in turning. Care in obtaining a rigid support for the tool is even more important in turning than in grinding. This is one reason it is advisable to remove an armature to a lathe whenever possible as a lathe is usually designed with a more rigid tool support than can be built up on the frame of a machine.

Final surfacing after turning requires more care than after grinding due to the "threading" effect of the cutting tool. One method is to remove the tool ridges with a light file cut, using a "chalked" file, afterwards polishing the commutator with a hand stone or very fine sandpaper. Another method, after turning the commutator, is to grind it with a stationary stone mounted in the tool post, running the armature at as high a speed as will allow smooth cutting. It is then given a final polish with a hand stone or very fine sandpaper, the commutator running at full speed.

After a commutator has been finished by any of the foregoing methods, it should be thoroughly cleaned, the armature carefully blown out to remove all copper chips and dust that may have lodged in the windings, the surface closely inspected and any copper that may have bridged across the mica removed. It should then be given a high potential test, 1000 to 2000 volts, to make sure that there are no grounds. These precautions will be found well worth the time they require in the subsequent troubles thereby avoided.

Grinding and turning each have certain advantages as a method of trueing a commutator. Probably, all things considered, better results will be obtained from grinding when properly done. Less copper will generally be removed from the commutator by this method. The face of each segment will have a true curvature. This condition, as has been pointed out, is not always attained in turning; the cutting tool may twist the segments enough that one edge is cut slightly deeper than the other. Grinding, unlike turning, can be done with the commutator running at full speed and any distortion due to this speed eliminated.

Turning is the best method for shaping up a newly built commutator. It is more rapid than grinding for trueing a commutator that is in bad condition. If the commutator has been well tightened and a very light final cut is taken the inequality of depth at opposite edges of the segments will be slight and may be removed by a final surfacing with a stone mounted in the tool post. There are many different machines and devices manufactured for performing the above operations on various sizes of commutators.

The new plant at Imatra designed to furnish power to the greater portion of South Finland, the building of which has been going on for the past year, will soon be ready for the installation of turbines and generators. The construction of this plant is the result of a scheme to harness the energy of the largest rapids in Finland, Imatra. The power plant itself will cost approximately 160,000,000 Finish marks, it is estimated, and the trunk transmission line an equal amount.

P & A

The First Train Run from the Reading's Camden Terminal on Day of its Formal Opening—Engineman Bidding Goodbye to His Mother

Testing Lubrication Electrically

A unique arrangement for the purpose of testing the qualities of various kinds of lubricating oils used in shaft bearings appears in a recent issue of Power. In substance it consists of a simple electric bell circuit as is shown in the diagram where *A* represents the bearing, *B*, the shaft and *C* a brush, held so as to be in contact with the shaft which has been previously cleaned to secure a good electrical contact. A switch, two cells of dry battery, and a bell comprise the other essentials of the circuit, the other end of which is connected to the bearing. A very thin film of oil will break such a circuit. Since the purpose of the oil in the bearing is to reduce the friction and wear to a minimum, by placing a film of oil between metallic surfaces no metallic contact occurs, if this film is complete, and the electrical circuit should remain open as long as the shaft is revolving.

A heavy oil was first put in the bearing and the switch closed. The bell began to ring vigorously showing that a complete circuit had been made. The shaft was then rotated at a normally operating speed and under normal conditions of load. At the end of half a minute, the bell ceased to ring constantly but did nevertheless ring at intervals.

A lighter oil was then substituted, all of the heavy oil having been taken out. When the circuit was closed, the

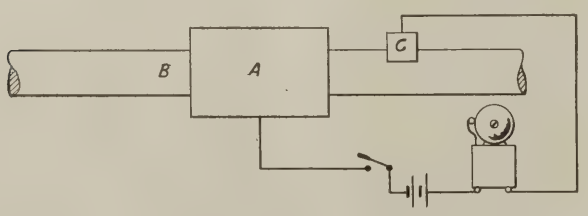


Diagram of Connections for Testing the Lubricating Properties of Various Oils

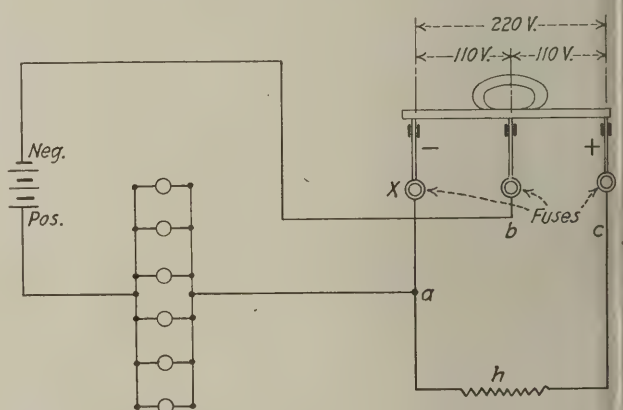
bell rang vigorously as before, but when the shaft was rotated under the same conditions of load and speed, the first few revolutions of the shaft served to quiet the bell entirely and it did not ring again until the shaft had stopped and the pressure of the shaft had squeezed out the film of oil.

It was plainly demonstrated that the heavy oil formed its film slowly and did not maintain it constantly there being metal to metal contact occasionally. The light oil proved superior in that it formed the film quickly and was fluid enough to keep a constant film between the shaft and the bearing surface.

A Queer Case of Battery Charging

By A. Foreman

A short time ago I had occasion to charge my rad battery on a direct current power circuit. I connected s lamps in parallel and put these in a series with the batte in the usual manner after first testing the line of polari so that I would get the positive side of the line connect to the positive side of the storage battery. After a tir I took a hydrometer reading and found that the batte was taking charge so I proceeded to forget about it for couple of hours. Imagine my surprise, upon making t next test, to find the battery totally discharged; dead the proverbial doornail. The lamps, being connected



Circuit Connections Where Reversal of Battery Occurred

series, showed that the battery was taking charge so concluded that the battery had either suddenly given the ghost like the "one-hoss shay" or else the polarity the line was wrong. I was positive, however, that I h made the connection correctly—but I tested it nevertl less, as a last resort. I received my second surprise five minutes when I found that such was unmistaka the case. Had the power been off during the time question I might have blamed the power company reversing the line, but I knew that the lamps had be burning brightly all the while so I decided that the trou was somewhere in the building. Upon questioning boys I found that one of them had found a fuse blown the main switch and had replaced it, so this gave m clue to the whole trouble. The condition I discovered best explained by means of the accompanying diagram

The power service is 220-110 three wire direct curr as shown. At the time I connected the battery to line the fuse was blown at x in line *a*, but I obtair

urrent from line *c* through heater *h* which was turned on t the time, to line *a;* thence through the lamps and batery to line *b,* it being noted that line *c* is positive to line . This caused the current to flow into the positive side f the battery as I had intended.

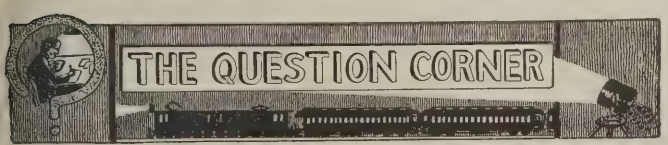
However, when the defective fuse was replaced the attery actually became connected across lines *a* and *b,* ut since *b* is positive to *a* the current flowed from *b* to the egative side of the battery and out to *a* thus reversing he battery. The lamps must have flickered for an instant t the time that the fuse was installed, but this would ot be noticed of course, unless one were looking directly t it at the time and even then it would possibly not have een attended to if nothing further happened. When I sked the workman, how he came to discover that the use was blown he said, "Oh the heater was not as hot s usual so I thought I would see if the voltage was low."

Passing the Buck

It's a mighty hard thing to acknowledge a fault;
It is human to hedge and deny,
Make excuses and stall, when we're backed to the wall,
Instead of the truth give a lie.

It's a mighty hard thing to admit we have erred,
But, like other hard things, can be done;
It takes courage and grit to say, "Yes, I'm it!"
But it's great when the battle is won.

It's a mighty hard thing to peach on one's self,
To say, "Yes, you're right, I'm to blame!"
But it takes out the sting and half squares the thing,
We can do it and will, if we're game!



Answers to Questions

1. Is it possible and practical to close a hole in a broken casting as indicated in Fig. 1, *using the electric arc welding process and a piece of tank steel?—J. W. M.*

Patch Welding in Cast Iron

1. It is entirely possible to do the job referred to in the question by the electric arc welding process and if the work is performed properly, the job will be satisfactory. The first thing to do is to bevel the edges of the hole. Then cut a piece of boiler plate and bevel that also as shown in Fig. 2. Next drill and tap the beveled edge of the hole in the cast iron and put in studs; probably ⅝-in. studs will be best for this particular job. It is not necessary to put studs into the steel patch. After the studs have been applied, the plate can be clamped or back welded in place temporarily until the welding is started. To insure proper strength the number of studs should be such that the cross section of the studs is equal to about 1/3 of the cross section of the iron at the break. The manner in which the work should be done is shown in Fig. 2. If extra strength is required, another row of ½-in. studs may be placed along the edge of the hole on the outside and then a pad put over the top of the weld including these studs as shown in Fig. 3.

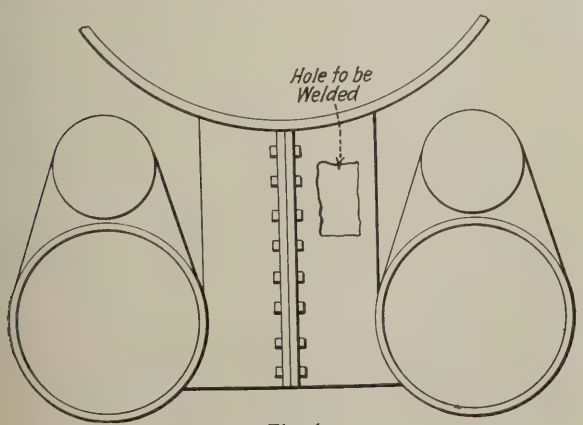


Fig. 1

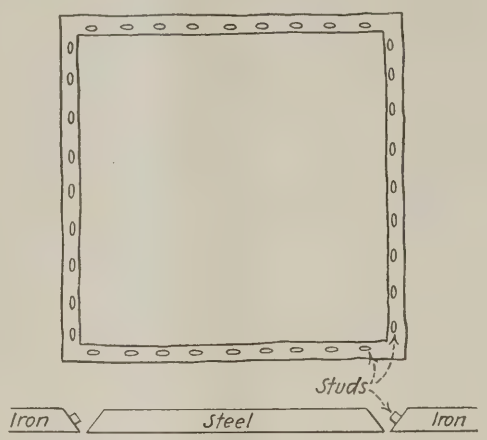


Fig. 2

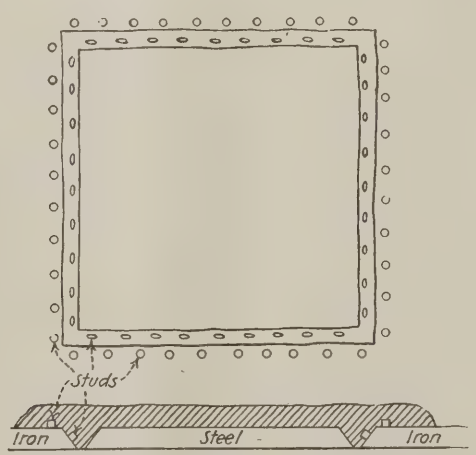


Fig. 3

Questions for June

1. What is the first thing to be done when a generator refuses to motor?—H. H.

2. What is the best method of procedure in order to bring a cell that has dropped in voltage, up to correspond with the others of a set?—H. W.

3. Do temperature changes affect battery capacity and how?—M. G.

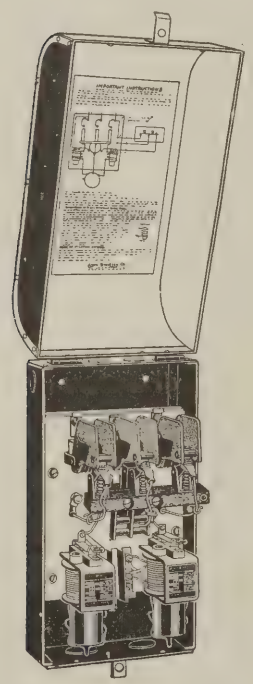
NEW DEVICES

New Line of Resistance Starters

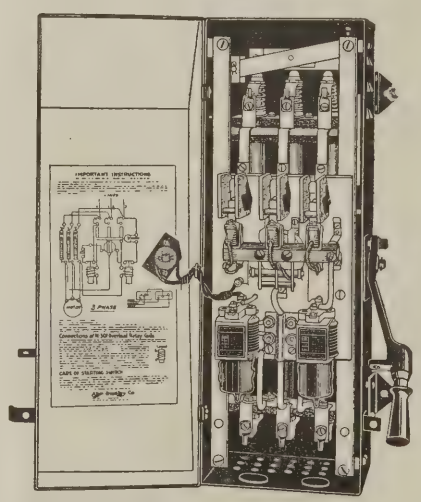
A new line of resistance starters and across the line switches for induction motors has recently been placed on the market by the Allen-Bradley Company of Milwaukee. The first of these is known as type J-1552 and is called an "across the line starter." It is a push button starter for squirrel cage motors up to 25 hp., 220 volts, and 35 hp., 440-550 volts and self-starting polyphase motors up to 50 hp. It is equipped with inverse time limit overload relays, no voltage release, push button station and copper to copper rolling contacts. It is enclosed in a steel cabinet and operates entirely from a push button station with a start and stop button.

The semi-automatic resistance starter, type H-1852, is a new and improved resistance starter for squirrel cage motors up to 30 hp., 220 volts and 50 hp., 440-550 volts. Stepless acceleration and smooth increase in starting torque without excessive starting current is provided by using graphite compression resistors. The motor is started by lifting a starting handle quickly to the mid position after which the handle is slowly lifted and the magnetic switch closes, thus throwing the motor on the line without opening the motor circuit. Arc shields and blow-outs are provided in all phases.

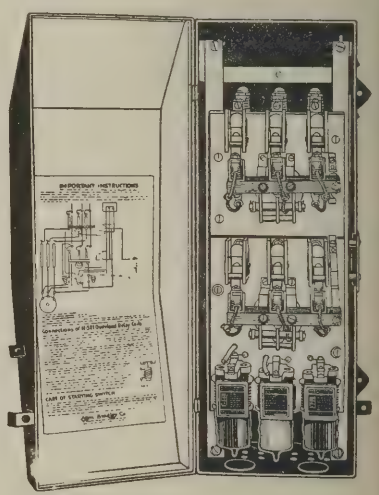
A third starter is also a push button controlled device and is known as type J-3052. It likewise has smooth acceleration due to graphite compression resistors. The graphite compression resistors are adjustable with one adjusting screw for any starting current and there are no taps to change. The motor is started by pressing a starting button on the push button station which closes the starting clapper switch and allows the motor to accelerate with the primary resistors in the motor circuit. After a fixed interval of time, the time relay closes the main clapper switch and throws the motor on the line without opening the primary circuit and thereby short circuits the starting resistors. This automatic resistance starter has all of the protective features of the starters previously mentioned.



Across-the-Line Starting Switch



Semi-Automatic Resistance Starter



Automatic Resistance Starter

Solder Pot With Automatic Heat Control

An electric solder pot with automatic heat control has been added to the line of devices manufactured by J. D. Wallace & Co., Chicago, Ill. The automatic control simplifies the problem of heating babbitt, white metal, wax and other materials that are slow conductors of heat. The main objective in its design is to overcome oxidation and it so operates that when the solder has been heated to 600 deg. F., an automatic control prevents a further rise in temperature. This control is an adaptation of the principle used in the steam gage. A volatile substance, which is very sensitive to heat, actuates a Bourden tube, which makes and breaks the electric circuit, thus controlling the temperature of the contents of the pot.

The pot will accommodate 15 lb. of solder and will heat this amount to 600 deg. F. in 20 to 25 min. Its quick action is due to the fact that a 900-watt heating element is built around the entire container and heat is thus applied to all parts of the sides and bottom of the container simultaneously.

This Solder Pot Minimizes Oxidation by Thermostatic Control

Once the container is filled and current turned on, it requires no attention until refilling is necessary. The pot weighs only 13 lb. and operates on either 110-volt or 220-volt alternating or direct current.

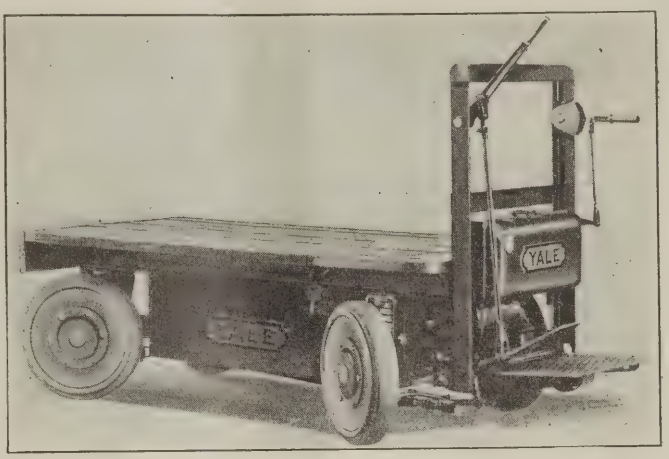
A Series of Industrial Trucks

The Yale & Towne Manufacturing Company, Stamford, Conn., is manufacturing five new types of industrial trucks, known as the K-20 to K-24, inclusive. This set constitutes a complete series of trucks, each of which is designed to fill a definite place in the scheme of material handling around a railroad shop.

The K-20 model is designed to meet the general requirements of intraplant movement. It will handle miscellaneous units of material which may be placed on the platform by hand, hoist, or overhead crane service. The auxiliary equipment designed for it includes a gravity dump body for handling loose material and an electrically operated swinging boom crane. It has large wheels and full spring suspension which permits of operation over rough surfaces. The controlling mechanism is especially constructed to facilitate handling in narrow aisles and congested places. All parts are easily accessible and are grouped in self-contained major units. The truck has a rated carrying capacity of 4,000 lb. and can be turned in a radius of 91 inches. The wheel base is 58 inches and the overall length is 102¼ inches, with an overall width of 84 inches.

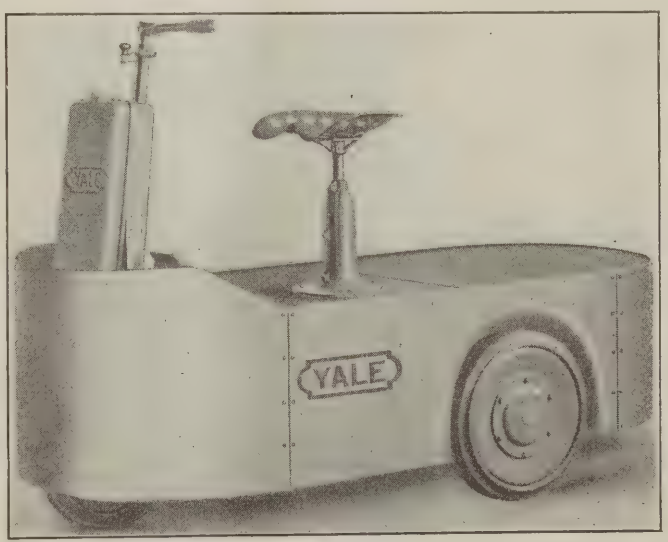
The model K-21 truck is similar in form to the K-20, but is equipped with a wider platform.

Model K-22 is a self-loading transportation unit in



Model, K-20, High Platform General Utility Truck

which are combined the advantages of high and low lifting. It may be used to lift loaded skids from the floor, transport them to a given place and raise them to a higher level in order to facilitate stacking or tiering in a storeroom or freight car. This model has a low center of gravity and the longitudinal frame members are made of pressed steel, which permits it to carry a 4,000-lb. load.



Model K-24 Is a Cimbined Tractor and Truck for Operation in Congested Spaces

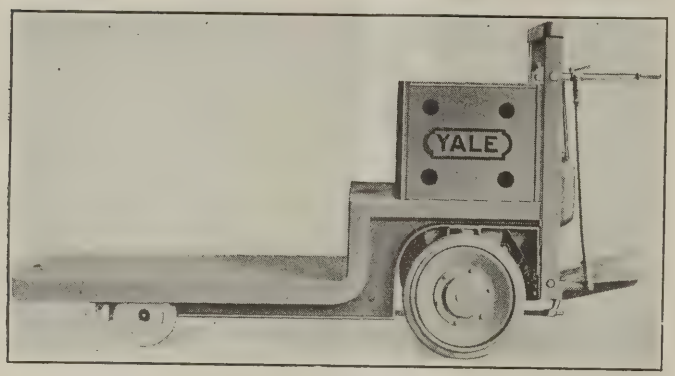
The lifting and lowering mechanism is of the triple, spur-geared reduction type, electrically driven. It is equipped for electric braking and has a mechanical auxiliary lowering-speed control with automatic upper and lower limit stops.

The Model K-22 truck has a wheel base of 55 in. and the overall height is 105 in. It can be turned in a radius of 84 in. and will travel at a speed of 6¼ miles an hour on a level concrete roadway, with a load of 4,000 lb.

The Model K-23 is a general utility truck and is designed with a low platform to reduce heavy lifting to a

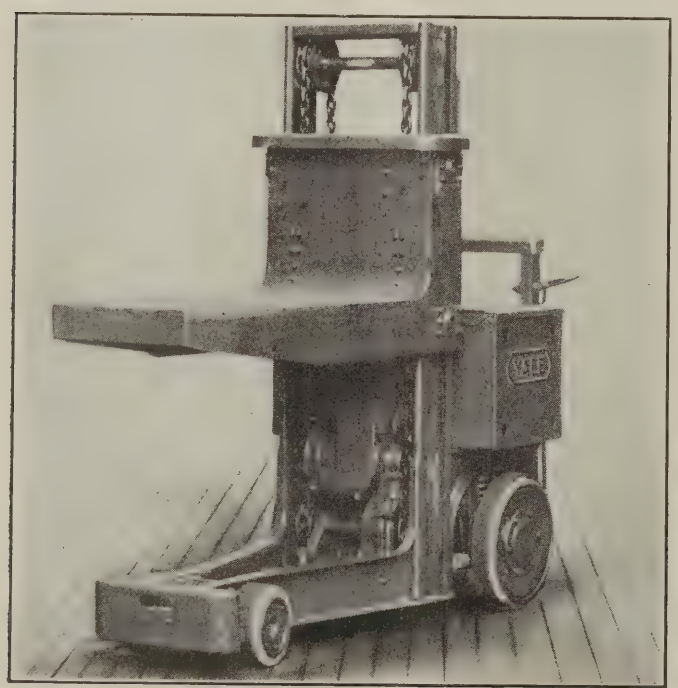
minimum. It is built for heavy duty and for operation where the road surface is in average good condition. Its over all length is 110¼ in. with a wheel base of 55¼ in. and can be turned in a radius of 89 in.

This company has also placed on the market a three-wheel truck known as K-24. Its platform area of 15 ft. is 70 per cent of that of the Model K-20 truck. It is



K-23 Is a General Utility Truck Built for Heavy Duty

capable of passing through a 3-ft. doorway, and may be carried on a 7-ft. elevator. This machine has a low center of gravity which is designed to prevent bucking, overturning against stalling loads, or tipping over sidewise while rounding a corner. The frame is made of heavy pressed steel and contains the battery compartment, bumpers and deck, which makes a solid and rugged one-piece structure. It is suspended on helical springs over



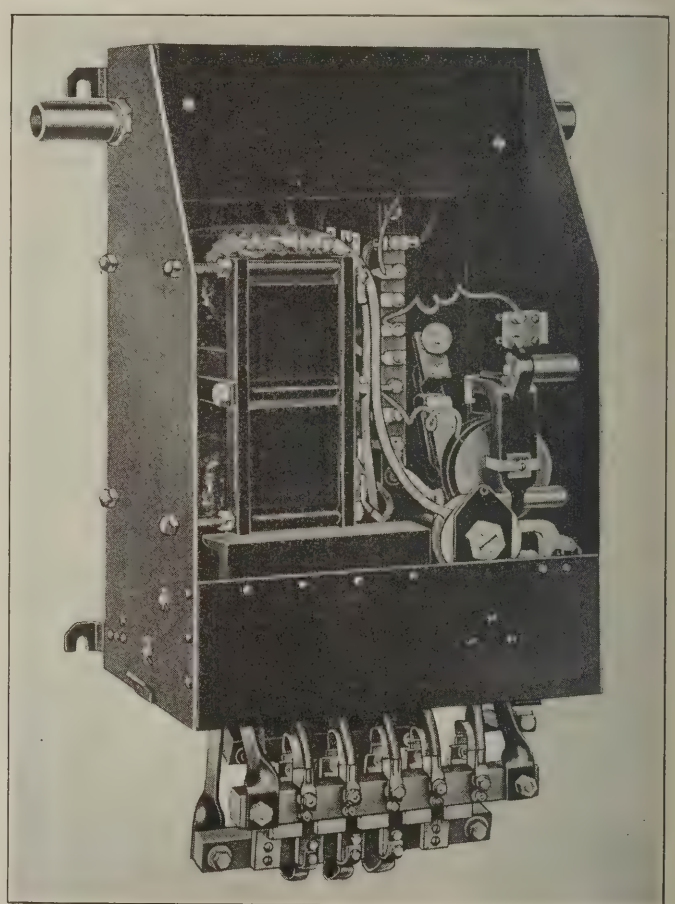
The Elevating Platform Truck, Model K-22, Is a Self-Loading Transportation Unit

each wheel. The seat is further protected by an additional spring of the swivel type, which enables the operator to get on or off the machine with greater facility and to look or reach back to the coupling point. The clear deck gives him unobstructed vision of the drawbar, which is essential for safe fast operation.

With the exception of the Model K-24, the various parts of these trucks are interchangeable with each other. The five trucks are equipped with spur-geared unit power axles, which are identical and interchangeable with all of the trucks of the K series. Heat-treated alloy steel and ball bearings are used throughout.

Starting Compensator and Magnetic Contactors

The Electric Controller & Manufacturing Company of Cleveland, Ohio, has recently brought out a new line of magnetic contactors for alternating current service. These contactors are single pole, double pole and triple pole. They are used for the control of wound rotor motors, for starting large squirrel cage motors across the line and for a variety of other purposes. The outstanding feature of the design is the elimination of slate mounted panels as the contactors are attached to the switchboard frame by

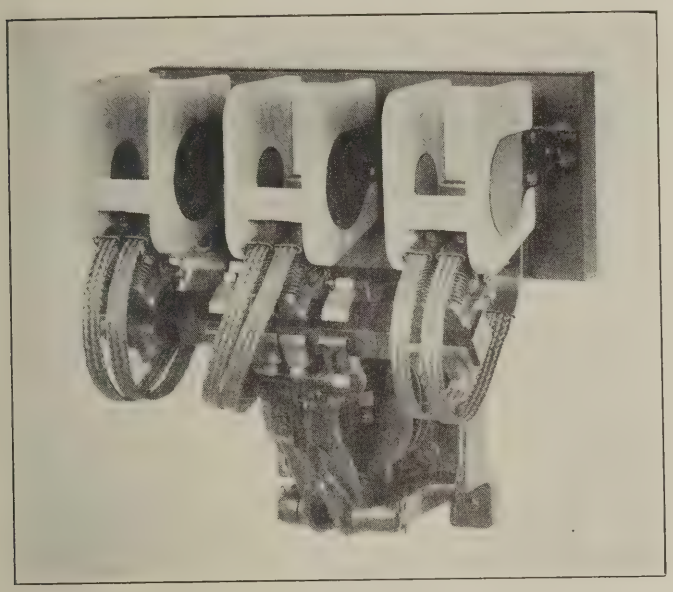


Compensator with Cover Removed

means of a cast iron housing or base of the conductor itself.

A manual automatic starting compensator for a. c. squirrel cage motors has also been recently introduced by the same company. These compensators combine most of the desirable features of the full automatic compensator in that the operator has no control over the rate of acceleration. He cannot hold the motor on the starting transformers longer than is necessary to bring the motor up to speed and he cannot throw the motor over to full voltage before proper acceleration has been attained. He simply pulls the handle into the starting position and the motor accelerates automatically. These compensators use the improved temporary relay overload device giving protection during starting as well as while running.

The line of squirrel cage induction motors which was first put on the market in 1922 by the Electric Controller & Manufacturing Company and which is known as the type N. C. has been very materially enlarged since it was first introduced. The motors are now available for 110,

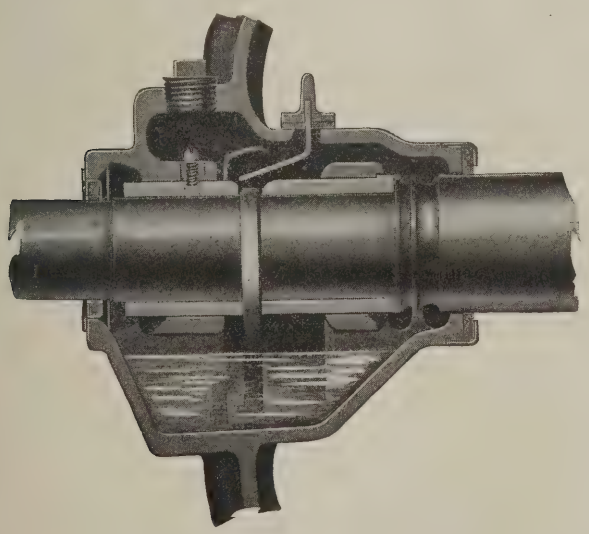


Triple Pole Magnetic Contactor

220, 440 and 550 volts, for 2 or 3 phases, at 60 cycles or 25 cycles as desired. The horsepower rating ranges from 1 to 75 for the 60 cycle motors and from 1 to 50 for the 25 cycle machines.

Leakproof Sleeve Bearing for Electric Motors

A new type of sleeve bearing for electric motors designed to prevent the leakage of oil into the windings or the entrance of dust and grit into the bearing, has been developed by the Westinghouse Electric & Manufacturing Company. This new bearing, which is known as the Sealed-Sleeve bearing, is so constructed that it is almost



The Sealed Sleeve Motor Bearing

air tight, preventing air from getting in and oil from leaking out.

The principal methods used to improve the conventional bearing are comparatively simple. A connecting passage in the upper part of the bearing housing secures a condition of balanced air pressure in the separate chambers into which the housing is divided by the bearing supports. The action of the blower at high speeds sets up a vacuum next to the inside end of the housing and, since it is impossible to seal the housing absolutely at that point because the shaft passes out there, the vacuum is communicated to the space within the housing itself. If the upper passage were not provided, an unbalanced air pressure would result whenever the oil level rose high enough to close the lower cored openings.

For inspection of the oil ring, a large air-tight threaded pipe plug is provided. An enclosed combination filling and overflow opening is placed in the side of the bearing and a rigid cast iron cover is bolted over the oil ring slot and made air tight by an oil proof packing.

Where the shaft passes through the bearing, an improved method of supporting the felt dust-proofing washer is used. For the purpose of lending resilience to the soft felt, the metal cap has a diameter at least ¼ inch larger than the shaft diameter. This prevents the felt from being compressed close to the shaft, which would cause it to become glazed and hardened and to soon burn and wear out. Since it is left free to expand, it acts like a brush and does not mar or glaze.

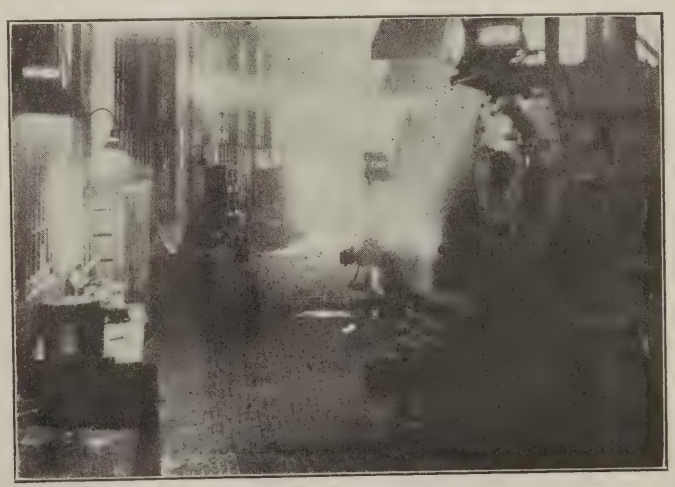
The air tight construction of the bearing prevents a fine spray of oil from being sucked into the motor.

No gritty substances can enter to mix with the lubricating oil and cause wear of the bearing shell or shaft.

The bearing requires practically no attention and oiling once or twice a year is generally all that is necessary.

A New Line of Floodlight Projectors

A complete new line of seven Davis floodlighting projectors has been recently placed on the market by the Western Electric Company. While the line is limited to seven different types, the range they cover is sufficient to



Enginehouse Equipped With Davis Floodlight Projectors

meet practically all requirements in the floodlighting field. As a result of combining the ideas and experience of lighting engineers and users of floodlights in a wide variety of applications, many new and unique features are incorporated in these units.

The Davis line includes a new searchlight, beam lights and floodlights and there are similar lighter weight units

for general utility purposes. These units meet the illuminating and physical requirements common to a wide variety of more usual uses to which floodlights are put.

Ironclad Storage Battery for Car Lighting

An Exide Ironclad type of storage battery for car lighting service is now being made by the Electric Storage Battery Company, Philadelphia, Pa. The outstanding advantages offered by this type of battery are its small size and light weight as compared with other types of lead-acid storage batteries of equal capacity. In addition

A 300 Ampere Hour Ironclad Battery for Car Lighting Service

to this, it is a rugged type of battery which will withstand a large amount of rough handling and vibration to which passenger coaches are bound to be subjected at one time or another either in the yard or on the main track.

The battery is made up in two-cell units, two cells being placed in a solid wood tray. The plates are of the Ironclad type and rest on cast ribs in a rubber composition jar. The plate groups or elements are each provided with two terminals which are connected as shown in the illustration.

Electric Device for Testing Transformer Oil

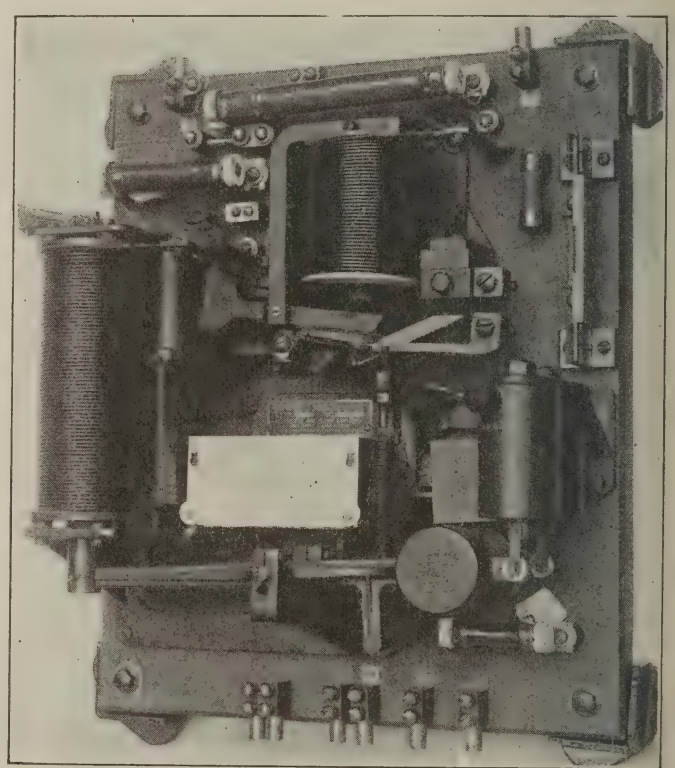
To facilitate the testing of oil in transformer drums, without the necessity of drawing samples, a new device has been developed by the General Electric Co., which can be used in connection with any 25 or 30 kilo-volt testing transformer, with the exception of those having the middle point of their high tension winding grounded. By means of this new tester, the oil testing gap is inserted into the drum through the bung and an immediate indication of the condition of the oil is given.

The tester consists of a standard 1/10 in. oil spark gap mounted in the lower end of an insulating tube. The leads to the electrodes are brought up through the tube to terminals mounted on the upper end. A gage is provided for checking and adjusting the spacing of the gap and, to prevent the loss of this gage, a receptacle is provided at the top of the tester into which it can be screwed when not in use.

The length of this tester, 32½ inches, and its light weight, 4½ pounds, make it well suited to uses requiring transportation from place to place. Its long, cylindrical shape permits easy storage when not in use. A flexible, weather-proof carrying case is furnished with the tester, which is the first of its kind on the market.

Improved Generator Regulator

An improved generator regulator has been developed by the Safety Car Heating & Lighting Company, New Haven, Conn. It is called the Universal Generator Regulator. One of the principal improvements consists of an arrangement on the back of the regulator which makes it interchangeable for service with any capacity generator and accordingly effects a reduction in the number of parts which need to be carried in stock. The current regulating coil and main switch series coil are wound for 25 and 50 ampere capacity only, but the connections are so arranged that a regulator with 25 ampere coils can be set for either 25 or 40 amperes and the regulator with



Safety Universal Generator Regulator

50 ampere coils can be set for either 50, 75 or 100 amperes.

When this generator regulator is applied for use with a generator having capacity less than the maximum setting of the regulator, a fibre cap is applied to the cut-out stud so that the regulator cannot be set above the maximum capacity of the generator. If it is later found desirable to use a higher capacity generator with this same regulator, maximum setting is obtained by substituting a brass cap in place of the fibre cap.

General News Section

J. D. Wallace & Co., Chicago, has recently moved into its new factory at 134-158 South California avenue.

The Chicago, Milwaukee & St. Paul has moved its general offices in Chicago from the Railway Exchange building to the new Union Station.

The Simmons-Boardman Publishing Company has opened an office at San Francisco, California, at 74 New Montgomery street. Homer Beach will be in charge.

Economy Fuse & Mfg. Company, on June 1st, removed its Chicago district sales office from 536 Transportation Bldg., to larger quarters at 513 West Jackson Boulevard.

A. E. Tregenza, formerly sales manager of the Economy Fuse Company, has recently left that company to become associated with the Chicago Fuse Company, as assistant to the President, in charge of commercial relations.

The Railway Service & Supply Co., and the Transportation Devices Corporation, Indianapolis, have recently opened a Chicago office in the McCormick Building, 332 S. Michigan avenue. W. C. Miner, who has been made sales manager, will be in charge.

The Interstate Commerce Commission's report to Congress for March on the condition of railway equipment shows that during the month 5,083 locomotives were inspected; that 2,674 were found defective and 468 were ordered out of service. Also 99,234 freight cars inspected, of which 4,461 were found defective; and 1,814 passenger cars, of which 41 were found defective.

Electrical suburban trains ran out of St. Lazaire station, Paris, for the first time on April 27 under the plan for the electrification of the suburban lines. The trains were run to Bois Colombes in which village is the stadium where the Olympic games are to be held this summer. The trains resemble the all-steel trains of the New York subway and are labeled as being absolutely incombustible.

The Union Pacific has organized a standardization committee which is visiting every shop on the system investigating methods and apparatus with a view to increasing efficiency. The committee consists of J. W. Highleyman, assistant superintendent of motive power and machinery, J. J. Kelker, superintendent of shops at Pocatello, Idaho, W. R. Ladd, superintendent of shops at Portland, Ore., and A. S. Norris, master mechanic at Los Angeles, Cal.

Work has been started on a new building seven stories high to include about 180,000 square feet for the Western Electric Company at Allegheny avenue, Clearfield, Ormes and B streets, Philadelphia, Pa. The new building will be used as a telephone distributing house, and it will include office, warehouse and shop space. The building is being erected by a realty corporation, and upon its completion will be turned over to the Western Electric Company on a twenty-year lease. The entire project will cost about $900,000.

The Chicago, Milwaukee & St. Paul is sending one of its largest electric locomotives on a three-months' tour of the states east of the Mississippi to allow the people of that part of the country to become familiar with the locomotives used in the Cascade Mountains. The engine will be exhibited in Detroit, Mich., Cleveland, O., New York, Philadelphia, Pa., Boston, Mass., and other New England cities. It will then be taken to Washington and Baltimore and from there will be sent back to Chicago. The engine will be accompanied by a coach fitted up with a lecture room and a car for the use of members of the party. Motion pictures of electrified trains moving through the mountains will be shown.

The possibility of the development of an aluminum alloy at a cost that would enable its use in locomotive and car construction, with a large reduction in weight and consequent decrease in the cost of transporting freight, was suggested by Gen. W. W. Atterbury, vice-president of the Pennsylvania Railroad, in testifying before the Senate committee on agriculture on April 19 in connection with the bid made to the government by himself, J. G. White and Elon M. Hooker for the Muscle Shoals property, which Henry Ford is also seeking. The cheap electric power available at Muscle Shoals, Mr. Atterbury said, would give an opportunity for experimentation to reduce the cost of the metal to a practicable figure. The metal would not have the strength of high carbon steels, but it could be used as a substitute for steel in a large part of either car or locomotive construction. He said it might be possible to cut down the weight by 50 per cent; and although the question whether it is possible to produce the aluminum composition at a cost which would make its use for cars feasible would have to be demonstrated, the efficient production of aluminum at low cost is directly dependent upon cheap electricity. General Atterbury said that the metal he has in mind would have approximately 25 to 35 per cent of the weight of steel.

Airplane Service in Canada

A novelty in train service will be tried out this summer by the Canadian Pacific on the line which has been built to take care of the traffic in and out of the new gold fields in Rouyn Township, Quebec Province. This new El Dorado is to be made accessible to travelers by the aid of water plane service beginning on May 18, the name of the new company being the Laurentide Air Service, Limited, of Montreal. Acting in conjunction with the Canadian Pacific that air service firm will operate a flying boat from Angliers, the end of the new Canadian Pacific line, to Lake Fortune and Rouyn. Large flying boats capable

of carrying five passengers will meet all C. P. R. trains to provide transportation for prospectors, tourists and supplies over the 50-mile gap between the end of steel and the gold fields. The flying boats will make the trip at a speed of about 100 miles an hour, thus cutting the normal traveling time over this difficult country from two days to fifty minutes. Before the introduction of the airplanes, the trip into the gold field by land and water required 2½ days.

Successful Year for Swiss Federal Railways

For the first time since 1913 the Swiss Federal Railways in 1923 had a successful year, according to Commerce Reports, the net results showing a small profit after payment of interest on loans and on floating debt, redemption of notes and deposits made to special funds. This hopeful outlook of the state railways for 1924 is felt to be one of the most encouraging indications that the economic position of Switzerland is gradually righting itself.

Both passenger and freight traffic showed satisfactory increases as did revenues, while operating expenses were lowered by reducing the number of employees and their wages, by increases in the hours of labor and by reduction in the cost of coal. The price paid for the latter in 1922 was 158 francs per ton, while in 1923 the price was 65 francs. [The Swiss franc is worth 17.5 cents at present exchange rates.] The total saving on coal in 1923 approximated 40,000,000 francs, part of which may be attributed to the increased electrification of the railways. Perhaps the outstanding feature of the year was the lowering of the operating ratio from 88 per cent in 1922 to 69 per cent in 1923.

An exceptional element contributing to the good showing was the unusually heavy east-to-west traffic between Paris and Vienna, caused by political developments beyond the Swiss borders. This advantage lasted from February till late in December and had a decidedly favorable influence on the results for the year.

During 1923 the Federal Railways carried 86,883,670 passengers, as against 81,032,550 in 1922. The revenue from this traffic in 1923 was 126,582,633 francs, compared with 121,130,930 francs in 1922, an increase of 5,451,710 francs.

In 1923 a total of 14,652,370 tons of merchandise was carried, compared with a traffic of 13,245,115 tons in 1922. The gross earnings from this source were 219,739,925 francs, an increase of 15,508,033 francs over 1922.

The total revenue for 1923 shows an increase over the previous year of 21,222,075 francs and aggregated 365,437,524 francs. The gross operating expenses, amounting to 306,287,299 francs in 1922, were reduced to 251,880,593 francs in 1923.

The Swiss railway budget for 1924 allots a total of 72,342,550 francs for construction. Receipts for the present year are estimated at over 375,000,000 francs, and the estimated expenses approximate 278,000,000 francs. The program for electrification will be accelerated as much as possible during 1924. All sections of the country demand their share of this new mode of traction.

The following lines are not electrically operated: Isel-Brig-Sion, Bern-Scherzlingen, Chiasso-Lucerne, Goldau-Zug, Immensee-Rothkreuz, and Lucerne-Zurich—a total of 256 miles. Electrification has begun on the Lucerne-Basel, Thalweil-Richterswil, Zurich-Bern, Sion-Lausanne, Lausanne-Vallorbe-Yverdon lines—a total of 241 miles. The Rennes-Geneva line is on the program for electrification this year.

It is believed that 1924 will prove even more successful than last year in spite of the fact that reductions in passenger fares will probably be made and perhaps in freight rates as well. Betterments are planned in the matter of train schedules; and increased tourist traffic, reduced labor cost and lower fuel prices are also expected.

G. R. S. Train Control on the New York Central

The apparatus to be furnished by the General Railway Signal Company for automatic continuous inductive train control on the New York Central Lines is to be installed first on three 10-mile sections of three roads, as follows: Boston & Albany, between West Springfield, Mass., and Westfield; C. C. C. & St. L., between Mt. Jackson, Ind., and Washington; Michigan Central, between Dearborn, Mich., and Wayne. Each of these three preliminary orders calls for equipment for 10 locomotives.

American Rail Motor Cars Prove Success on Foreign Railways

Rail motor coaches of American manufacture, in operation on the British section of the Kowloon-Canton railway since 1922 have proved a success, reports Consul Leroy Weber, Hongkong. While this equipment, according to the railway officers, is in the experimental stage, these cars have rendered good service at an economical cost, fulfill the requirements for a light train, for working up new traffic and for development and emergency purposes. The only difficulty encountered in operation has been the delay in securing spare parts and replacements. This should be easily remedied.

The introduction of rail motor cars on the railways of South Australia likewise proved so successful, according to Consul H. H. Balch, Adelaide, that all the states of Australia may adopt this type of passenger vehicle for feeder and short lines in less populous territory. The first 2 of 12 cars ordered from an American company have already arrived and have been installed after successful trial trips. It is said that the Chief Commissioner of Railways plans to purchase about 100 additional rail motor cars for passenger service on the South Australian lines during the next two or three years.

The New South Wales government is experimenting with rail motor cars built in its own shops, but it is understood that the cost is much greater than that of the American cars. The Tasmanian government also has the matter under consideration.

Progress on the Moffat Tunnel

The pioneer or water tunnel at the east end of the Moffat tunnel which is now being driven through the Continental divide on the line of the Denver & Salt Lake in Colorado had, on April 10, been driven in 2,100 ft. from the east portal and 2,340 ft. from the west portal. The main heading of the railroad tunnel has been driven 1,450 ft. and the full section 135 ft. from the east portal, while at the west portal 680 ft. of main and top headings have been excavated. A total of 500 men are now being employed, in three shifts, working on seven headings.

The Automatic Train Control Situation

Franklin Snow, who has interviewed many railroad officers and other persons on the subject of automatic train-control, and some of whose articles have appeared in the Christian Science Monitor, gives his conclusions in the Monitor of May 6. To equip 141 engine divisions, would, in the present state of the art, be "futile." Standardization to make apparatus usable on two or more connecting roads is declared to be highly essential. He thinks the railroads unduly disturbed by unreliable estimates of probable high cost, but admits that the lowest reliable estimates call for very heavy expenditures. The demand of the railroads that the automatic apparatus be left (under suitable restrictions) within the control of the engineman is declared to be a vital issue; as is, also, the demand that no system or method be ordered or used which cannot be suspended whenever conditions are such that an accidental or unnecessary stop is likely to cause serious and costly blockades.

Collision in Switzerland Kills Thirty

On April 23 at Bellinzona, Switzerland, at 2:20 a. m., a Basel-St. Gothard-Milan night express train collided head-on with a Milan-Basel express train resulting in the death of from 20 to 30 persons. Each train was drawn by two locomotives.

All the passenger cars were of wooden construction and some of them were lighted by gas which ignited the wreckage and burned many who were entrapped—hence the difficulty of stating the exact number who lost their lives. The accident was said to have been due to a mistake made by a switchman in throwing a switch. One of the passengers killed was Karl Helfferich, former Minister of Finance of Germany.

Virginian Wants I. C. C. Approval of Train Control Before Installation

The Virginian Railway has filed with the Interstate Commerce Commission a petition asking that it be not required to make an installation of automatic train control, saying that if the commission's orders are to be construed as requiring carriers to select and install at their own risk a system of automatic train control without approval by the commission of the system, plan or design until the completion of the work by the carrier it "respectfully protests against being compelled to assume such risk."

Electrical Industrial Truck Manufacturers Join in Co-operative Program

Electric industrial truck manufacturers in co-operation with The Society for Electrical Development have started plans for a co-operative educational program. At a meeting held at the headquarters of the Electrical League of Cleveland on May 9 it was unanimously decided to launch a business-building program in parallel with the Electric Truck Business Development Program, under which the manufacturers of electric street trucks, batteries and accessories with the co-operation of the Transportation Bureau, N. E. L. A., and The Society for Electrical Development are working together along educational lines. The plan was unanimously adopted by the Automatic Transportation Company, Baker R. & L., The Crescent Truck Company, Elwell-Parker Electric Company, Lakewood Engineering Company and Yale & Towne Manufacturing Company, which attended the meeting. It is anticipated that the other companies will also subscribe to the idea and another meeting to crystallize the jobs to be done will be held at the time of the American Railway Association convention at Atlantic City, on June 16.

Long Island to Begin Electrification of Additional Line

Construction work on the electrification of the Jamaica to Babylon line of the Long Island Railroad will be started within the next few weeks. This information was given out together with a statement that a contract for $700,000 of new equipment which will be used to install six substations along the route had been awarded to the Westinghouse Electric Company.

Contracts for the long ties to support the third rail were awarded some time ago, and word has been received by the company that the first shipment of these is now en route from Florida. The twenty-six miles of third rail which is to be used by the company as a part of the installation will be rolled by the Bethlehem Steel Corporation. Delivery on this is expected shortly, and the engineers of the Long Island Railroad anticipate putting down some of the new rail before the end of June.

Delivery of the electric equipment from the Westinghouse Electric Company will be made in November and will be used to complete the construction. Power for the operation of the equipment over the Jamaica-Babylon line will be obtained from the central power house of the Long Island Railroad Company.

Electrification to Proceed in Sweden

Following the electrification of the Swedish State Railroads between Stockholm and Gothenburg, now making rapid progress, it is proposed to electrify at least ten of the railroads in private ownership.

The ten private lines which are being studied with a view to electrification by a special commission all run through central and southern Sweden in the most densely populated and most highly industrialized regions of the country.

Closely related to the progress of railway electrification in Sweden is the news that the Waterfalls Administration has requested from the Riksdag an appropriation of $1,600,000 toward the construction of a new hydro-electric plant in northern Sweden. The new plant will be built on the Umeaa River and will utilize a waterfall purchased by the Government in 1917 for $536,000. It is expected that work will begin this summer.

Six New Storage Battery Cars on C. N. R.

The Canadian National recently commenced to operate six new storage battery cars. Three of these cars will run from Montreal to points nearby and will add considerably to the suburban sevice at present being given by the system.

One of the new storage battery cars will be placed on the Tunnel Terminal route from Montreal to St. Eustache

and will provide five additional round trips per day between these two points.

On May 19, one of these cars began operation from the St. Catherine Street East station of the Canadian National between Montreal and Rawdon. One of these storage battery cars will provide daily service between Montreal, Granby and Waterloo, leaving from Bonaventure station. Of the remaining three cars, one will be placed in operation between Ottawa and Pembroke, another betwen Toronto and Oakville and the third will be used for relief purposes.

These cars are 53 ft. long, about 9 ft. wide, 12 ft. high, have vestibule ends and can be operated from either end. The interior has a mahogany finish and is equipped with canvas-lined rattan seats. There is seating accommodation in each car for fifty passengers, in addition to baggage space.

Trade Publications

The Packard Electric Company, Warren, Ohio, has just issued a 16-page illustrated pamphlet known as Bulletin 202—A. The bulletin describes the construction and use of the A-W Regulators which are designed for the control of series lighting circuits.

The Martindale Electric Company, 11727 Detroit Ave., Cleveland, Ohio, has recently issued a new four-page illustrated folder specializing on commutator slotting equipment. The folder also contains a number of other items of interest to electricians incidental to the care of motors.

The Borden Company, Warren, Ohio, has just issued an eight-page envelope folder illustrating the new large sizes of Beaver Square End pipe cutters. By the application of a new method the operator is able to cut the large sizes by hand with speed and ease, or to apply power when desired.

The Ohio Electric & Controller Company, Cleveland, Ohio, has recently issued two bulletins illustrating and describing its products. The first of these bulletins is No. 204. It gives a description of fractional sized a. c. and d. c. motors. The second bulletin shows a number of applications for these motors.

Johns-Pratt Company, Hartford, Conn., is distributing a small folder illustrating and describing the Noark service box for industrial power circuit control. The outstanding feature of this box is the fact that the switch and cut-out are contained in one unit, the fuses being removed from the circuit whenever the cover of the box is opened.

Roth Brothers & Co., Chicago, Ill., manufacturers of constant potential battery chargers, have recently published a new bulletin No. 135 entitled "Questions and Answers on Constant Potential." The bulletin covers the subject of constant potential charging. It also gives complete information regarding Roth chargers and will be sent upon request.

Annealing of castings and wire, heat treating, calorizing, sherardizing, and other processes using electric furnaces are shown in a new bulletin, No. 48721, recently issued by the General Electric Company. The publication is mostly pictorial in content, illustrating the application of this type of heat to various operations in plants of that company. Details as to heat, dimensions and function of each installation shown are given in descriptive captions. The bulletin is entitled: "Direct Heat Electric Furnaces in General Electric Factories.

The Crouse-Hinds Company, Syracuse, N. Y., has just issued two publications. One of these, known as bulletin No. 2057, describes vapor proof condulets with reflectors. This bulletin contains 12 pages illustrating the various types of reflectors used with different sizes of lamps. The second publication is a large folder illustrating special condulets for concealing in concrete.

The Allen-Bradley Company, Milwaukee, Wis., has just issued four illustrated bulletins describing new products. Bulletin No. 720 contains information about a new "Across the Line Starter" known as type J-1552. Bulletin No. 740 shows an automatic resistance starter type J-3052. Bulletin No. 600 deals with alternating current starters and bulletin No. 640 describes semi-automatic resistance starters, type H-1852.

Wires and Cables.—An attractive 36-page booklet, 9 in. by 12 in. in size, entitled "Okonite Installations," has been issued by the Okonite Company, Passaic, N. J. The booklet consists entirely of full-page illustrations showing applications of Okonite wires and cables. These applications include 6 power house installations and 27 railroad installations including stations, shops, signals, interlocking plants and electric traction.

Okonite Installations.—The Okonite Company, Passaic, N. J., has recently issued an attractively bound, large size, 36-page, illustrated booklet on installations made by this company. Each page is devoted to a large illustration of one installation at one particular point and covers such features as cable crossings, signals and interlocking, electrification, power houses, terminals, etc., at different points about the country and on a wide variety of railroads.

The Westinghouse Electric and Manufacturing Company has recently published an eight-page circular, known as C-1694, entitled "Supervisory Control." In this circular the general principles of operation and construction of both audible and visual systems of supervisory control for automatic substations are set forth.

The circular is amply illustrated with photographs of the control apparatus and diagrams of the two types of control systems. It is a publication that should interest everyone connected with the generation and distribution of power.

The Performance of Instrument Transformers is the title of a publication recently issued by the Westinghouse Electric and Manufacturing Company for distribution to electrical engineers and to students of engineering who are interested in instrument transformers. The new 32 page book, which is known as Special Publication No. 1696, analyzes the factors underlying the performance of both current and voltage transformers and gives complete information for the successful application of these transformers to an electrical system. Wiring diagrams for instrument transformers have been included in the publication, together with a table of operating constants for Westinghouse instruments. Ratio and phase angle curves for both voltage and current transformers for 25 and 60 cycle operation are likewise included for the purpose of ready reference.

Railway Electrical Engineer

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The June Convention

The semi-annual convention of the Association of Railway Electrical Engineers which met in Atlantic City on June 12 was the largest attended meeting that the association has ever held at that place. The growing importance of the association was reflected in the scope and character of the reports presented. Electrical equipment is coming into such extensive use on the railroads that it begins to look as if eventually it will not be possible or at least not practical to attempt to cover all of the work of the association in a single day. As it was, the session lasted until 7 p. m. and at that much of the discussion had to be curtailed. Each year seems to bring additional problems to the electrical men and each convention brings reports on new subjects. Among the new committees this year, were the Committee on Safe Installation and Maintenance, the Committee on Electric Storekeeping, and the Committee on Starters and Controllers. In addition to these, there were 11 other committees dealing with subjects which have been presented before. It is certainly most interesting to look back upon the work of the association years ago and compare it with the work that it is doing today. In the beginning, car lighting was the major, if indeed, not the entire subject for discussion, whereas today the association has 14 committees covering a wide range of subjects and there is indication that even this large number will be further increased.

Moreover, the character of the discussions which take place today in connection with the reports is of a decidedly higher quality than in the years gone by, which shows unmistakably that the electrical men have risen to their opportunities and are handling in a masterful way the many and varied problems which are constantly coming up for solution.

How Associations Can Co-operate

The Association of Railway Electrical Engineers seems to have established a relationship with the Mechanical Division of the American Railway Association which is productive of useful results and entirely satisfactory to both associations. If the A. R. E. E. men were to work entirely independently, the results of the work done would lack importance in the minds of many who ought to use them. On the other hand, if the A. R. E. E. were to become a section of the Mechanical Division, their work would be overshadowed by that of the larger body. Furthermore, most of the electrical work is of a special nature, the details of which are not of interest to the majority of members of the Mechanical Division. The affiliation between the two bodies is difficult to describe, but it results in complete agreement on all subjects of importance. No actual relationship exists between the two associations except for the fact that certain men are members of committees in both associations. It may be said, however, that the Mechanical Division lends the A. R. E. E. the advantages offered by its position and prestige while the A. R. E. E. acts as specialist or advisor to the larger organization. The situation provides an excellent example of how different technical bodies interested in allied subjects can work together to excellent advantage. In this way a maximum of work is accomplished without duplication of effort, the time of a large body is not taken up with details and special work is done by specialists.

Best Practice Manuals

The Association of Railway Electrical Engineers is nothing if not practical. Each year of its existence it has grown and expanded both in membership and in the scope of the problems which it has to meet. The association has already published books on the subjects of car lighting and locomotive headlights and now proposes to develop a manual on electric welding as used in railroad shops. That this will be a most important addition to the literature on this subject is assured for the reason that the committee which has this work in charge expects to handle the matter composing the manual in a thoroughly practical manner. It is pretty generally known that all welding jobs are not universally successful. Some roads seem to be able to accomplish results which other roads apparently are unable to obtain. If a certain kind of welding job can be done in one locality, there is no good reason why it should not be duplicated in another and yet the evidence shows that this is not the case. There can be only one explanation for this and that is that the unsuccessful weld has been attempted without complete information as to the proper method of procedure. It is the purpose of the committee on electric welding to prepare the manual so that each and every one of the important details which enter into a successful weld will be fully explained by text and illustration so that the best practice may be universal on all roads. Moreover, it is the intention to design a manual as a looseleaf book so that new and better methods can be substituted for older ones as fast as they are developed. The amount of detail work in connection with the compiling of a manual of this type is tremendous and the committee is to be highly complimented on its courage in undertaking a task of such

magnitude. The support of every member of the association should be given to the committee by reporting all welding work of an unusual nature which has proved successful, and there is little doubt but that when the manual is completed it will be one of the most valuable factors in railroad shop welding.

A manual on illumination has also been suggested by the committee on this subject. The gradual issuing of lighting codes by the various states and the need for reliable information along these lines to serve as a guide for those who have to lay out these lighting problems are principally responsible for the proposal of such a manual. Railroad lighting in every phase is constantly becoming a more important factor in operation, and the compilation of reliable information on this subject would be most welcome. The committee does not expect to bring out such a manual in the near future but rather to gather the data together on the various lighting problems to be met, with the idea of eventually compiling this data into a manual. Railroad shop lighting, roundhouse lighting, yard lighting, scale lighting, warehouse and pier lighting, car lighting and miscellaneous lighting problems are the subjects upon which the committee expects to secure information.

It is clearly obvious that the program as outlined represents no small task as is also the case of the welding manual; but, it is readily apparent that it will render a wonderful service to the members when once it is available. These two manuals, proposed by the Association of Railway Electrical Engineers, give abundant evidence of the practicality of the organization. It is meeting its problems in a practical way and it is no exaggeration to say that the work which it does is second to none that is being undertaken by any railroad association.

Needs of the Welding Field

Fusion welding as applied to railroad shop practices is the source of much argument and discussion among the various people concerned. Many welders are piqued because the rigid limitations imposed on welding as applied to railroad equipment do not permit the welder to show what the possibilities of welding are. The limitations are in some cases more rigid than are warranted, but all railroads cannot do as good welding work as some and the welding practices on equipment that is interchanged must necessarily be restricted to such practices as are successful on all roads concerned.

The amount of welding work which is being done by the railroads is increasing, however, and the railroad men are endeavoring to take full advantage of this useful tool. If this increase is to continue and all roads are to profit by developments in the art, the work done by the several societies and associations interested in the subject of welding must be co-ordinated. The Association of Railway Electrical Engineers is preparing a manual on electric welding as used in railroad shops. This will be available to railroads when finished. Its compilation will require much work and when completed it will be composed of useful, practical information. Its usefulness will, of course, be limited to electric welding. More information is needed. The American Welding Society has unofficially offered its help. The Gas Products' Association, the Master Boilermakers' Association, the American Electric Railway Association and the American Engineering Standards Committee can similarly be relied on to fulfill a want. What is needed most at the present time is co-ordination of the work done by these several bodies so that the most important problems will be given priority and no two societies will waste their efforts by compiling similar information.

New Books

Direct Dynamo and Motor Faults—By R. M. Archer, 204 pages, diagrams, 7 in. by 5 in., bound in cloth. Published by Isaac Pitman & Sons, London and New York. Price $2.25.

This little book is intended to assist students and those in charge of direct-current machinery in the location of sources of trouble and in the application of proper remedies. Part one describes the more common faults that arise and the symptoms that their occurrence causes. In part two the arrangement is by symptoms, with appropriate diagnoses of the trouble.

Conduit Wiring—By Terrell Croft, 458 pages, illustrations, diagrams, 9 in. by 6 in., bound in cloth. Published by McGraw-Hill Book Company, New York City. Price, $3.00.

This book is devoted exclusively to the conduit method of interior wiring. It is intended primarily for the man who installs wiring, and who will find here a more detailed exposition of this method than that given in most books on interior work. The steps and operations necessary in modern work are discussed and explained, and the usual procedures in wiring buildings of all kinds, from small residences to large office and shop buildings, are set forth.

Electrical Engineering Practice—By J. W. Meares and R. E. Neale, 584 pages, illustrations, diagrams, tables, 9 in. by 5 in., bound in cloth. Published by John Wiley & Sons, New York City. Price $6.00.

This work endeavors to fill the gap between the pocket-book of bare data and the highly technical treatises for specialists in various branches of electrical engineering. It is intended for civil, mechanical and electrical engineers alike, who wish a reference book covering the whole field in reasonable limits. Four editions have been called for in eight years. The new edition has been enlarged and rearranged and published in two volumes. The first volume treats of definitions, materials, measurements, the generation and sale of electrical energy, and its transmission and control. The treatment is practical throughout.

Storage Batteries—By George Wood Vinal, 400 pages, 156 illustrations, 6 in. by 9 in., bound in cloth. Published by John Wiley & Sons, Inc., New York City. Price $4.50.

The book summarizes the physical and economical facts and theories about storage batteries and describes their various applications. It lays emphasis on the scientific principles involved without further permitting the text to become so technical as to restrict the general usefulness of the book. It is not in any sense of the word a repair manual. It discusses the storage battery from the economical and physical standpoint and also from the practical side of the question.

The first chapter contains a general treatise on the subject of storage batteries and the remainder of the book is grouped under nine titles as follows: Materials and Methods of Construction; The Electrolyte; Theory of Reactions; Energy; Transformations and Voltage; Capacity; Efficiency; Testing Storage Batteries; Present Day Usage for Storage Batteries.

Hotel Dennis, Atlantic City, Where the A.R.E.E. Convention Was Held

Railway Electrical Men Meet in Atlantic City

Semi-Annual Convention of the A. R. E. E. Held at Hotel Dennis with Record Breaking Attendance

THE fifteenth semi-annual convention of the Association of Railway Electrical Engineers was held in Atlantic City at the Hotel Dennis on June 12. The room in which the meeting was held was filled to capacity, the number of persons present exceeding that of any previous spring meeting held by the association. Abstracts from the discussion are given in the following pages:

In opening the meeting, Mr. Lunn, the president of the association, spoke in part as follows: "It gives me pleasure to welcome you to the meeting and to invite you to listen to the reading of the various progress reports which will be presented and which represent the thoughtful effort of your fellow members who have willingly consented to assume the responsibility of placing before you, and others interested, their latest findings relative to the most up-to-date practice in the subjects covered.

"The progress reports representing, as they do, in each case, not the opinion of an individual, but of a group of men, trained to meet the problems presented, should be given your careful consideration, and where criticism is warranted let it be forthcoming, and, if commendation is justified, a little encouragement will do no harm.

"We can look back on some worthwhile achievements as an association and feel hopeful for the future. The successive reports of various committees have covered the respective fields fully and standards recommended have been quite generally adopted.

"The report of the Committee on Data and Information submitted at last fall's convention, showed the use of electrical devices to be rapidly increasing on railroads and the discussion which followed its presentation clearly indicated the necessity for alertness on the part of the electrical engineers, whose duty it should be to give not only opinions when asked for, but to initiate improvements, the carrying out of which would be reflected in worthwhile economies.

"Our association is somewhat unique in that it includes in its membership not only men of electrical executive training and technical men, but those who have by reason of their thoughtful study and experience in handling equipment qualified themselves to pass intelligent opinions on the many problems which must be faced in railroad work.

"The officers and members of the various committees have our sincere thanks for their unselfish efforts in making this meeting a success."

Immediately following the address of the president, the report of the secretary-treasurer was presented. In view of the short time available, Mr. Andreucetti, the secretary-treasurer, gave a brief verbal statement in which he stated the membership of the association to be 450, and the financial resources to be approximately $3,800, with no liabilities.

Power Trucks and Tractors

The first report to be presented was that of the Committee on Power Trucks and Tractors, and L. D. Moore,

of the Missouri Pacific, and chairman of the committee, opened the discussion as follows:

"Mr. President and Gentlemen: I had hoped that this report would be in the hands of the members in sufficient time for them to digest the questions which the committee asked and answer them here for the record. However, I believe the report did not get out in sufficient time. There are a couple of additional questions that have come up since the report was submitted. One of them is in connection with crane type trucks, and is a matter of electric slew, that is, moving the truck sideways versus the hand slew. The other question is the matter of batteries. The committee would like to have expressions as to whether equally good results can be obtained from the nickel iron Edison battery and various types of lead batteries and whether the capacity-reducing effect of extreme cold weather seriously limits the usefulness of either on safe installations."

Mr. Colegrove (Ill. Cen.): "It is reported that some railroads make over model T Fords into tractors by installing a jack shaft back of the main axle and connecting the two by a double chain drive. Can the committee give us any information regarding the use and adaptability as performed by the electric tractors."

Mr. Moore: "The committee is not in a position to answer that right now. Possibly some of the members can answer it. I think some of them have been making those changes and using that sort of equipment. That is just the kind of information the committee would like to get."

The President: "We have several tractors of that type, and comparing them with the service that we get from Fordsons or from the Shop Mule, it is far superior. It has apparently the right amount of power, and the speed is more adaptable to all classes of tractor work around the shop than either the Shop Mule or the Fordson tractor. The repairs appear to be much less than would be necessary to make to a model T running at regular speed."

Mr. Billau (B. & O.): "I should like to call attention to a feature of the truck question which I believe was brought up last year, and that is that serious consideration be given to the question of battery box dimensions for industrial crane type of trucks that would permit the use of railway types or sizes of batteries. On the B. & O. we have carried that practice out quite extensively, using Edison batteries, and have found the practice very satisfactory."

Mr. Voight (Santa Fe): "While I have not taken exact dimensions of the space allowable on a truck for such interchange as Mr. Billau has mentioned, yet it would seem to me that in view of the fact that most railroad companies are going to deeper mud cellars, it would make it almost impractical to use the room where you use a three-inch mud cellar."

The President: "I infer from Mr. Billau's remarks that he refers principally to Edison batteries, and not to lead batteries."

Mr. Cartwright (L. V.): "I would suggest that the association take a stand on the size of battery boxes on trucks and tractors and recommend to the builders of trucks and tractors that they provide a battery box with their equipment sufficient to take the size of battery such as we use in car lighting."

Mr. R. M. Mulholland (Automatic Transportation Co. of Buffalo): "We, as well as all of the other truck manufacturers, are now supplying battery boxes sufficiently large to take as high as A-8 Edison or a 19 plate Exide. It is not practical or possible in the restricted state in industrial truck construction to get in as big as an A-12 Edison battery, which I believe is the size universally used in car lighting."

Mr. Billau: "Practically the only feature that has given trouble is the question of the height of the battery box. We are using both, in car lighting and in trucks, the 225 ampere A-6 capacity battery and the A-8. The point that I was bringing out was the desirability of having sufficient height to permit using the H type of cell, which is standard in car lighting service as compared with the lower cells that are frequently used in truck service. Our experience has been with all types of trucks in which the battery is mounted above the platform, that with a little effort the design can be made such to take those higher cells."

Mr. Voight: "May I ask Mr. Billau what particular advantage are you getting from this interchangeability?"

Mr. Billau: "Our main asset from the use of interchangeability of the batteries is reducing stocks of spare batteries to be carried. That has been a very marked advantage in our case."

The President: "Have you anything further to say, Mr. Moore, in regard to your report?"

Mr. Moore: "I would just like to say this. We would appreciate a letter discussion so that the committee may be in position to digest the experience of the members and as far as practicable embody it in their next report."

Mr. Colegrove: "I would like to ask what the roads using the crane truck at their roundhouse have done to keep this truck busy all the time? I found in one of our shops where the foreman has laid out a regular program, that the truck worked on a schedule, and he increased the use of his truck about two-thirds of what he ordinarily got out of it before he established a system and put it on a schedule. These various gang foremen lay out their work so that they figure on getting this truck a certain time and they keep that truck going all the time. He claims that he has relieved a labor gang of ten men, dispensing with six of them and relieving four of the men for other work. A man and a helper have displaced ten men."

Mr. Jansen (Ill. Cen.): "I think we all ought to advocate good drives and good walks around the shops. Our main trouble has been that it has been hard to get between shop buildings with these crane trucks, especially in bad weather. If we all just keep after good drives and good walks, we will save expense in maintaining the trucks and facilitate the work a great deal."

Safe Installation and Maintenance of Electrical Equipment

This report was presented by Mr. Miller of the Chesapeake & Ohio, who spoke as follows:

"While in some instances, you will think that we are trying to say that work must be installed in a specific manner, we are not trying to do that at all or to try to get people to get away from their present day methods. But what we have been trying to do is to work up the report

in such a way as to keep people from getting hurt. I believe that was the idea of this committee being formed, that they wanted to reduce the number of accidents to a minimum, and that is the standpoint from which we work. We will be glad to have any suggestions or additions mailed to Mr. Sugg or myself. We feel that there are several things that we have not covered or even touched upon in this report, and for any who have suggestions to add to this, we will be glad to hear from you as soon as possible."

Mr. White (Okonite Co.): "I think that paragraphs 5 and 6, under the heading 'General,' and paragraph 6, under the heading 'Wiring,' unnecessarily limit the type of wire or cable to be used for high voltage—and here he interprets high voltage to be anything over 600 volts. For example, 2,200 volts is not considered high voltage today. Also I call attention to the fact that steel case armored cable or other types of steel armored cable are perfectly feasible construction, good construction and safe construction. I would ask the committee to consider the extension of those paragraphs to cover such types of construction. They are perfectly safe and reliable."

Mr. Jansen: "We have been for about eight years operating a tape braid cable, 600 volts, on lines where we have had a great many lightning discharges and lightning arresters, and have never had any trouble with cables. For that reason, I think that paragraph 6 under 'Installation' should be changed to 'Lead Covered Cable or Equivalent Protection,' and the same way with paragraph 5 under 'Wiring.' I also think that under 'Maintenance' this should be added, 'Don't work on high tension apparatus until you are sure it is positively disconnected from line and grounded.' The words 'and grounded' should be used. I should like to ask the committee whether a safety type disconnect switch should be installed at each motor to disconnect the starting apparatus before making repairs to it or to the motor—this in addition to the disconnect switch or the fuses in the panel box. It is our practice always to install the fuse safety switch ahead of the starting device."

Mr. Sugg (A. C. L.): "That was discussed in the committee and, according to my experience, we have had so much trouble in keeping the right kind of fuses that we have tried to get away from the use of fuses on all motors except in outlying points where we do not have the proper supervision. On motors of five horsepower and less, in some cases seven and one-half horsepower, we use fuses. But the other motors, where you get up to 50 or 60 ampere fuses and you burn out three of them every time—you find the electrician will pick up a piece of wire and wrap it around and he usually tries to hide it so that nobody can see it."

Mr. Jansen: "We would fuse the circuit in the panel box and place a fuseless safety switch just ahead of any starting apparatus to entirely disconnect the starting equipment from the line."

Mr. Sugg: "That is the intention, on all motors—to put in a fuseless switch."

Mr. Billau: "I should like to ask if the committee has given any thought or consideration to the question of the relative merits of refillable and one-time fuses."

Mr. Moore: "We have been using both kinds of fuses and I do not find that the renewable is doctored any more than the other one is."

Mr. Wanamaker (C. R. I. & P.): "We abolished all one-time fuses for a period of three years over the system to give the refillable fuses a chance. After three years we abolished the refillable fuse for two reasons: One was the unsatisfactory service; the other was that it was not as economical, strange as it may seem, as the one time fuse. We found that in refilling the fuses they did not get good contacts and therefore the refillable fuse was constantly letting go and even to the extent of destroying the container and the contacts."

Mr. Moore: "It seems to me that it would be well for the committee to consider the proposition of artificial resuscitation as a general practice around electrified shops. I know of one case where a man got mixed up with an extension cord. It happens in that case it was not low voltage. The transformer had broken down. An ambulance was called and they carried him off to a hospital several miles away. At the time he started, he was breathing, but when he got there, he was dead. If the prone pressure or other method of resuscitation had been applied immediately, the man probably would have gotten over it all right. In the new Cohokie Power Plant in St. Louis, a man recently bumped into 13,000, got his shoulder against it. He was a painter. The resuscitation was applied immediately, and aside from rather severe burns, the man is all right today."

Self-Propelled Cars

Mr. Gage of the Canadian National Railways presented the report, saying:

"Mr. Chairman and Gentlemen: I have had much pleasure in being associated with Mr. Wanamaker of the Rock Island, Mr. King of the Santa Fe, and Mr. Macnab of the Canadian Pacific on this committee of yours on self-propelled cars. As a committee we have given a lot of study to the subject, and we trust we will be able to get a satisfactory report at the end of the year."

The President: "This subject is destined to loom up big in the future, and as individuals and as an association, we are deeply interested in this important problem. Does anyone wish to say anything with regard to this subject?"

Mr. Cartwright (L. V.): "For the information of the members, I would like to state that since December 1, 1923, we have been operating a straight gasoline car with a seating capacity in coach section of forty passengers and in baggage section, eight, through a distance of 108 miles per day. We have kept very accurate records of cost of maintenance and the operation of the equipment. Since the first day of December, that car has only been out of commission one day, when it was taken out for a general overhauling inspection, and up to the present time, as compared with the cost of a locomotive and a combined car, we have saved over $1,800 a month in cost of operation. I think it is a subject that we should look into and get data on. I will be in a position, with the permission of our superintendent of motor power, to give very accurate data on the operation of an all-gasoline electric car at our next convention."

Mr. Wanamaker: "I might make a statement that would prove of interest here for those who would like to or might enjoy visiting the Chicago & Great Western two-car motor train that is on exhibit here. I rode it from Chicago to Atlantic City over the B. & O., and we

made a scheduled speed from Chicago to Atlantic City, exclusive of the ferry down at Delaware and across, of 38.25 miles per hour. To my knowledge, this was the longest motor run for a self-propelled vehicle or car that has ever been made. Between Baltimore and Philadelphia, a distance of 96 miles, we made the run without stop in two hours and six minutes, which was a little bit faster than the best scheduled passenger train. Over the Blue Ridge Mountains between Connellsville and Cumberland, we made a minute or two better time than that of the Capitol Limited. We only ran in the daytime. But at that sustained speed for two hours without a stop, when we arrived in Philadelphia, I put my hand on the radiator and you would hardly know that the motor had been running. There was not a hot bearing; there was not the slightest trouble with equipment."

Electric Welding

Mr. Wanamaker presented the report, which was chiefly concerned with a proposal that a manual on welding be prepared and published by the association. In opening the discussion on this subject, the president said:

"No more valuable addition could be made to the literature on the art of electric welding than the proposed manual. To publish such a revisable text book, for such it would be, would require a great deal of work and careful preparation, but the benefits to be derived will be so great as to warrant the effort. The subject is now open for discussion, and we shall be glad to hear from you."

THE SECRETARY: "Mr. Chairman, in summarizing the committee's report, what they want to know is whether it is the consensus of the association to go along with their program and prepare this manual. I move that the committee be instructed and given authority to go ahead and prepare the manual and have it ready, if possible, for the annual convention in October."

(Motion Seconded)

THE PRESIDENT: "Gentlemen, you have heard the motion. Are there any remarks?"

MR. BILLAU: "Mr. Chairman, I believe one of the criticisms that could possibly be made of the work that this association has done in the years of its existence has been, to a certain extent, its failure to present the work that had been worth while and of value to the members as well as to the railroads in such form as they can use it. I think it would be a very desirable step in the matter of a policy of the association to take work such as this and present it in some such form as a manual or working manual."

MR. BLISS (U. S. L.): "Mr. Chairman, as a representative of the manufacturer of electric arc welding apparatus, I would like to say that one of the most discouraging phases of this industry, or art, as it might be called, is to be found in the fact that we are confronted everywhere by the statement that a certain arc welding process cannot be carried out successfully in a certain locality or on a certain class of work. Every conceivable kind of work in connection with arc welding has been done successfully somewhere. The difficulty is to get the information passed about from hand to hand."

MR. CANDY (Westinghouse Electric): "The mere fact that some railroads have not recognized what other railroads are accomplishing with the welding process does not strike me so forcibly as that on some individual roads some shop superintendent will not know how to go about a particular job or know about the success that some other shop is having."

Locomotive Electric Lighting

Mr. Mulheim of the B. & O. presented the report and introduced the subject for discussion.

"On account of the difficulty of securing accurate photometric data for comparative purposes," he said, "it has been suggested that the matter be referred to the Bureau of Standards for a recommendation, but I believe that the railroads should be in a position to work out the problem themselves satisfactorily, and I think we can eventually do so. We no doubt will have something to report by the fall convention."

MR. MCGINNIS (Pyle National Co.): "Just in order to straighten out one point here for the record, in this committee's report of last year, this expression was used in the recommendation for photometer:

> 'The photometric distance should be fifty feet, and the focusing should be adjusted for maximum beam intensity *at this distance.*'

"Those three words are the ones I want to call attention to because in this year's report they mention that one test was made at fifty feet and the other at one hundred feet, but they have neglected to say that in the first case, the fifty-foot case, the beam focusing was brought to the maximum intensity at that distance. There is a good deal of difference. I would just like to have that rewritten to include those three words to make it conform to your recommendation of last year."

MR. MULHEIM: "It is my understanding the first test, as Mr. McGinnis has said, was made on the basis of fifty foot distance with the maximum beam intensity focus, while the second was for parallel beam at the one hundred foot distance."

MR. BILLAU: "I have two suggestions to offer in connection with the work of this committee. The first one applies particularly to the headlight committee. I believe it will be desirable for the committee to obtain such data as it can on the results that are being obtained with various kinds of insulated wire in locomotive wiring service. The other subject I suggest rather hesitatingly, because I appreciate the magnitude of the work and its difficulties. Train control will be used to a considerable extent on our railroads, and I think most of us feel that ultimately the electric power supply for such equipment will come from a single power plant on the locomotive. I think the time is ripe now for some association committee, through proper committees, to begin the study of that subject with a view, first, to collecting necessary data and gradually working to the point where they can develop a specification for a generating equipment of electric power plant on a locomotive that will ultimately take care of the requirements."

MR. MINICK: "On turbine generators for headlight service or for locomotive service, efficiency is low and regulation must necessarily be bad. Train control people have to adapt themselves to the conditions that actually exist. I would like to have that thing considered very seriously because it is placing a demand upon the railroads and upon the manufacturers of railroad equipment that is extremely severe and, to my mind, is to some extent unfair because of the extreme difficulty in doing it. I ques-

tion the advisability of the so-called permanent focus lamp for this reason: We all know how wrong work is done, how difficult it is to get extremely accurate workmanship on a device such as a locomotive which is traveling around over the system practically all its life with very little opportunity for readjustments. I doubt very much whether it will ever be possible to maintain a headlight in proper alignment even though it may be put in proper alignment when it is first applied to the locomotive. If it cannot be maintained in proper alignment, you must have some adjustment of the headlight lamps in order properly to place the beam of light."

MR. MCGINNIS: "I should like to ask Mr. Minick if he feels that by changing the position of the reflector, he could compensate for a misaligned headlight case."

MR. MINICK: "Not entirely so. It is very desirable, and I think a great many of the railroads do attempt to get their headlight cases properly aligned, but I do not think it is possible to keep them properly aligned at all times."

MR. COLEGROVE: "I would like to ask the committee whether anything has been developed to indicate that a shock absorbing socket such as a spring type is desirable especially for gauge and marker lamps to increase the life of the bulbs?"

MR. MULHEIM: "I might reply to that that the committee has had no information on that subject so far, but we will be glad to receive anything along that line that is available."

MR. MINICK: "I want to say just a word on this matter of shock absorbing devices. Personally, I am opposed to anything of that kind. I do not think it is good practice. It is inviting trouble. My feeling in that matter is to face the problem squarely, to pass the buck to the manufacturer."

MR. ZIMKOWSKY (New Haven): "Mr. Chairman, I would like to find out from the various members what method they use on switch engines, whether they are using a dimmer or not."

MR. COLEGROVE: "On our road we formerly used two 100 watt lamps on a switch engine, and we burned these lamps in multiple, using them both at once with a standard dimmer so that we would not have to carry two types of dimmers. We used practically the same switch on the road as on a switch engine, and where they found the light was too bright for close yard service, they threw on both lamps and burned both at the same time, and they used a dimmer, cutting the candlepower of the lamp. But we afterwards went to the 50 watt lamps, type B, which did not give us the distance, and we are now going to the 60 watt lamps, although we have not been able to determine yet just what the results will be. The law requires 300 feet and the enginemen want a light that they can see 300 feet."

MR. MINICK: "I, personally, have not come across any railroads yet that are using a dimmer on the rear end. Some roads have 250 watt lamps on the front end of switching engines and use it constantly with the dimmer in the circuit. That will give approximately the same amount of light as the 100 watt lamp without a dimmer."

MR. CARTWRIGHT: "I would like to ask about the location of the back-up light. On some of the roads I notice they locate it on one side, the left tank, others in the center, some of them up near the coal pile, and I would like to get a little information as to the general practice as to where is the best location for the back-up light on the rear end of the tank."

MR. COLEGROVE: "That would be a matter of personal preference on the roads, but I imagine that the general practice is to place it in the center at the top of the tank."

MR. MINICK: "The order respecting the back-up lights that was issued before the roads were turned back to private management, called for the light to be put in the center of the rear of the tank, at the top of the tank. Some roads shift it to one side or the other and keep close to the coal pile, but in general I believe you will find it about the center of the tank."

Electrical Storekeeping

In speaking on electrical storekeeping, the president said:

"This subject is one which is given all too little attention by electrical men generally. Storekeepers, as a rule, are not as familiar with electrical stock as are the men who have to use it. Neither are they as likely to appreciate with what care electrical materials should be handled in order that they will be fit for use when needed. They can hardly be expected to anticipate requirements in all cases. For these reasons, electrical men should keep in close touch with storekeepers and give every assistance possible to insure that enough of the right material is on hand, and it will not have to be rejected when required."

MR. COLEGROVE: "In the past five months our road has been making a general clean-up and the men have been instructed to turn back any material to the general stock that they could. In making a check over the system I found where they were turning back material in an unassembled condition, parts of fittings. I instructed them to take all of this material back and assemble it and turn it into the store department in such condition so that it could be sent out and used; otherwise, it lies on the shelves indefinitely because a complete fitting is wanted and they may have a part of a fitting. They may have all of it there, but it is in such a condition that it cannot be used."

MR. MULHEIM: "I would like to ask if the committee later intends to develop any particular system for electrical storekeeping; if it is the purpose of the committee to do so."

MR. WRAY (Railway Purchases and Stores): "The committee has in mind first ascertaining what systems are in use at the present time and also to find out what the general recommendation of the electrical department, of the signal department and of the storage department seems to be, and also to make a study of what the committee considers some of the best systems and to incorporate in our report all four of those ideas."

MR. MOORE: "I just wanted to ask the committee if it is their intention to consider telephone and telegraph material as well as signal and the ordinary so-called electrical material."

MR. WRAY: "I think that point is well taken. Where the telegraph and telephone superintendent is a separate official, not included under the signal department, he will receive the signal and telephone questionnaire to include signal and telegraph apparatus."

Train Lighting Equipment and Practice

Mr. Lunn presented this report, Mr. Billau occupying the chair while Mr. Lunn read the report.

MR. VOIGHT: "I just want to ask if there has been any trouble experienced with the 50 watt nitrogen lamp in regard to the strength of the filament as compared with the tungsten lamps. We have not been securing as good a light with the 50 watt nitrogen lamp as we were obtaining out of the tungsten lamp. While I have been in touch with the manufacturers, yet I wish to ask if any other roads have noticed the tendency of the filament to break on the 50 watt nitrogen more than on the 50 watt tungsten."

MR. JANSEN: "We have not experienced any trouble in that respect. In fact, we are going to increase our vestibule lighting by using 25 watt, type C, P-S 16 lighting and increase our center deck lamp from a 50 watt B, to a 40 watt, type C, P-S 20. I will say that where we put 40 watt, type C, in place of the 50 watt B, our illuminating has been greatly increased."

MR. CARTWRIGHT: "I would like to ask the members what experience they have had with regard to the anchoring of the filaments on car lighting lamps. We found on our road that about nine-tenths of our breaking of the filaments is due to the fact that we had no anchor on the filament itself, and on about 25 per cent of the lamps that we received from the lamp manufacturers there was no anchor at all."

MR. VOIGHT: "I should like to refer to another part of the report with regard to using pilot lamps. I realize that in the steel car construction, the fire hazard is not as great, but after talking it over with several of my foremen, they mentioned that they had quite a few failures of car lighting equipment due to the short occurring in the pilot lamp which did not permit the generator to build up, so there is another subject besides the fire hazard to be considered in connection with the fusing of the pilot lamp."

MR. JANSEN: "While I am on the committee, mechanical section, I was not present at the meeting when they voted to permit a fuse on the pilot light, but all of our steel cars have mahogany wood finish, and we have had a fire. I feel that every pilot light circuit ought to have a plug cut out."

MR. CALLAHAN: "I would like to ask whether the pilot light is of any particular value, and whether the train crews other than inspectors pay enough attention to its indications to warrant its installation and maintenance."

MR. BILLAU: "I might say that in our experience we found the best solution for the pilot light question is to get rid of it entirely, and have done so with the exception of official and dining cars."

MR. VOIGHT: "We have used pilot lamps for a good many years and found them of real value. In our instructions to the train crew, there is a special notice regarding the necessity of their observing the pilot lamp and wiring ahead in case of trouble, and it has certainly saved delays to trains in being able to have a repairman or two, if necessary, on hand to make repairs to that train."

MR. COLEGROVE: "I agree with Mr. Voight. On our road we have a number of trains that are operating where they do not receive attention other than that the train crew gives except at stated periods. We would not think of doing without the pilot lamp."

MR. SUGG: "Our experience has been the same as Mr. Billau's. We have done away with all the pilot lamps on the dining cars and official cars, too."

MR. WANAMAKER: "The East and the West do not agree, but here is something Mr. Voight and Mr. Colegrove brought out. We have electric lighted cars that the electrician sees twice a month, but the train crews have instructions to watch these pilot lamps. I think the reason the West differs from the East is that our lines are long and thin and the terminals are far apart, and we have no electricians for 300 miles."

THE PRESIDENT: "There is another question that I would like to hear discussed, the question of coach and suburban car lighting, and in the hope of bringing out some additional facts regarding successful operation of the different systems, I should like to ask Mr. Wanamaker what his experience has been."

MR. WANAMAKER: "Within the last three years, we have completed the electric lighting of all of our suburban trains, and to make a long story short, I might say that we have not received any complaints, as far as I know, within the past year on any of the trains which are lighted from the head-end."

MR. BOUCHE (Gould Coupler Co.): "Before this is closed, I should like to ask if any data is being compiled in connection with the broad faced pulley used in belt lines. We are called on to supply all sizes of them. We have got anywhere from a seven-inch face up to fourteen."

MR. BILLAU: "I might say from the result of the B. & O. experience, we have gone into it very carefully because we have adopted as a standard a 24-inch face pulley, straight faced. On cars such as baggage cars, express cars, running into yards, shop cars, where you would have extreme curvature to deal with, the increase in belt life has been 35 per cent of cars with a wide faced pulley. Where cars do not get into those yard conditions, the increase in life has been only 2 per cent."

Starters and Controllers

Mr. Bebout of the C. & O. presented the report and spoke as follows:

"It is not the object of this report to start a long discussion between the manufacturers. We are going to give you a chance at our next meeting. Of course, if there are any suggestions, we shall be glad to take them up now."

THE PRESIDENT: "The recommendations suggested by the committee can well be discussed at this time as they are the result of careful consideration by men who are qualified to outline requirements for advance practice."

MR. MOORE: "There are quite a number of recommendations given here as individual items, and it occurred to me that in making the report next fall, it might be well for the committee to discuss why they make certain recommendations. I would also like to ask the experience with push button control, that is, whether it has lived up to the expectations as to what it would accomplish, and as to whether in most cases the expense of it is justifiable as compared with the cost of manual control."

MR. WANAMAKER: "About three years ago, I think it was, we adopted automatic control for all shop equipment. I have found that you can buy control equipment at a very slight increase in expense over the old manual. The one that we used is based on the time element, and that

eliminated practically all our troubles with automatic control equipment. I should say it has reduced our motor troubles fully 50 per cent."

MR. BEBOUT: "Our recommendations are not entirely for push button control. While we favor the push button control in a good many cases, we do not recommend entirely, either the manual or push button control. I would like to say that we have been using push button control on our coal elevators with the remote control. They have the buttons in the basement, on the ground, and then on the top of the building, and it is convenient for the operators to stop the equipment or start the equipment at any point if anything should go wrong. In some of those controls we do not have any trouble within a year or two years. In fact, one plant has been running for about two years before we changed the oil in the controller. The manufacturer recommended that we had better change it once a year, whether we had any trouble or not. They have given us excellent service and reduced the maintenance. Where push button controls are serviceable or applicable to the service, I think it would be well to recommend them."

Economics of Electrical Appliances

E. A. LUNDY of the E. A. Lundy Company presented the report and spoke in part as follows:

"What we want to do is to get some of the major applications and find out the specific data that made possible the more efficient operation of railway facilities. We picked out some of the major applications in getting our questionnaire in shape, and we would like it very much if you have any thoughts that would be helpful in whipping this into final form."

MR. MINICK: "I have not had much opportunity to read this over, but in glancing over the questionnaire, it seems to me to be rather elaborate, and I was wondering whether the committee could not consistently reduce it to some extent for the reason that on the larger roads it is very burdensome to investigate all the questions that are asked and give proper and true information in reply. For instance, our road would probably have twelve to fifteen hundred turntables. Pretty generally they are operated electrically. It is going to take some time even to make a count of that many turntables. There is a lot of data of that kind that is going to be very difficult to get and get it quite accurately, and we do not want to put out anything that is not accurate."

MR. LUNDY: "We realize that in a large number of cases, possibly the railroads will not be able to furnish the information. We also appreciate the fact that some of them would, and what we were after was to get just a few comparisons."

MR. MINICK: "I may have been misunderstood. It was not my intention to omit information that was asked for so much as it was to reduce it to more general terms."

MR. WANAMAKER: "Such railroads as are not in a position to answer all the questions in the questionnaire, could they not just choose two or three typical installations that had been made wherein no doubt they had to submit estimates of savings in order to receive the authority for the expenditure? A well-managed road has no doubt to check it up afterwards to see if they made that saving—and would it not be an easy matter then for most any road to pick out two or three typical installations and furnish all the data and information requested?"

Sponsor Committee on Insulated Wires and Cables

Mr. White of the Okonite Company gave a brief summary of the status of the various sub-committees. No specification has been submitted to the sectional committee for a final report to be passed up as American standards.

Illumination

In presenting this report, Mr. Billau spoke in part as follows:

"The major subject that this committee was directed to handle this year was one of preparation of suitable data covering modern illumination practice applying specifically to the steam railroad field. What has brought about the need for such work is the gradual development or rather the gradual issuing of lighting codes by various states and their increasing activities along those lines, and it was felt that for the guidance of those on the railroads who have the laying out of these lighting problems, particularly the smaller installations and changes in lighting that are made from time to time, it would be very desirable, if not essential, that they be furnished with reliable advice on such subject matter. As a consequence the committee has outlined a program which will probably require several years in its preparation, and ultimately it will appear or probably develop in the form of a manual, at least as far as the form of the data is concerned. In what form it will be actually issued has not as yet been contemplated. The first section will cover general data on methods of handling illumination problems and layout. Other sections will cover railroad shop lighting, roundhouse lighting, yard lighting, scale lighting, station lighting, warehouse and pier lighting, car lighting, special and miscellaneous problems in illumination. It is the expectation of the committee this year to present in its annual report the first three subjects, that is, the general data, railroad shop lighting and roundhouse lighting."

Radio As Applied to Moving Trains

The committee did not present any report, but in connection with this subject, the president spoke as follows:

"It is known that this committee has some interesting things under way, especially in connection with recent installations on private cars, and possibly others, concerning which the committee has not been advised. The ground was fully covered in the report of the committee at the annual convention last Fall so far as the art at that time had progressed. Developments are coming so rapidly in this interesting and fascinating field, both in the perfection of receiving apparatus and in the number and character of broadcasting stations, that it is problematic to what extent railroads will be called upon to provide radio service on cars. Any interesting information or developments which come to your attention should be promptly reported to the chairman in order that the committee may have the benefit of your combined observation. In the absence of the report, a discussion on the subject is in order. I would like to hear from any of you, although we will have to limit the discussion to about five minutes. As a starter, I wish to read a telegram which I received last night from Mr. W. F. Williams, Superintendent of Telegraph of the Seaboard Air Line, which reads as follows:

> 'Radio all we expected. Have been in touch with some stations all way from Chicago to Boston. Much pleased with results.'

"I refer to this installation because it is the first one that the Pullman Company has ever applied to a private car, that is, permanently. Emergency installations have been made and temporary installations in quite a number of cars, but this particular car was fully equipped with what was supposed to be the latest type of radio equipment, and I am glad to receive this telegram from Mr. Williams that everything worked satisfactorily. I would like to hear from others in regard to it."

MR. OPELL (New Haven): "I applied radio outfits to private car 400, New Haven, and talking over with Mr. Towne, whose car that is, he tells me that he is getting results from it every day. He tells me that under a bridge, reception is not quite so good, but otherwise he gets most anything he is looking for."

MR. CARTWRIGHT: "Will the chairman tell us the type of equipment they had on that car?"

THE PRESIDENT: "We used a single loop aerial, the upper deck eight and a half inches from the upper deck horizontally and fourteen and a half inches from the curved part of the lower deck. It clears the clearance limitation about one and one-half to two inches. Horizontal brackets were brought out from the eave of the upper deck, and the only criticism that anyone could make in regard to the installation was that it was so inconspicuous that the average radio bug would not know that it was on. However, it was very pleasing to the railroad, because they did not wish to have it appear that they were running around in a radio car unnecessarily. They were not ashamed of it, but they did not like to have it look like a telegraph station moving around on wheels. The equipment, by the way, did not require the use of a ground wire, although one was provided in case they desired to use it."

MR. CARTWRIGHT: "How many tubes in the set, Mr. Lunn?"

THE PRESIDENT: "It was an 8-tube set."

Automatic Train Control

The president opened the subject, saying:

"It is understood that there have been no developments of importance since last year's annual convention. The committee is following the progress made on various railroads, and will report fully at next fall's convention. If anyone has any recommendations or suggestions to offer for the benefit of the committee, we shall be glad to have them now."

MR. WANAMAKER: "As a member of the committee, I know that they have done a great deal of work towards collecting the data necessary for the report this fall. We not only expect to have some construction data, but we will be able to submit this fall some operation data."

Power Plants

The Committee on Power Plants did not present any progress report but expects to have its report in readiness for the fall meeting. There was no discussion on this subject.

The meeting was adjourned at 2 p. m. bringing to a close the largest attended session that the association has ever had at its semi-annual convention.

When you are listening to a broadcasting station, you are at the receiving end of one of the smallest power units of which man has made any practical use. The minute quantity of energy utilized by each receiver to direct and control the local battery circuit has been made significant by Dr. L. R. Whitney, director of the research laboratory of the General Electric Company in the statement that: "If the amount of work done by a house-fly in crawling up a window pane for one inch were to be put in a receiving tube—as energy coming from space, it would suffice to actuate the outfit continuously for a quarter of a century."

Diesel-Electric Locomotive Built by Ingersoll-Rand and General Electric Companies Used in New York Switching Service by the New York Central

Headlight Maintenance on the Nickel Plate

Small Force Keeps Machines from Two Divisions in Good Order and Establishes Enviable Record

By H. A. Leatherman

THE servicing of the General Electric headlight turbines at the Stony Island shops of the New York, Chicago & St. Louis Railroad is an interesting illustration of what can be done with a few highly skilled mechanics and a minimum of equipment, the deficiencies in equipment being compensated for by the ingenuity of the

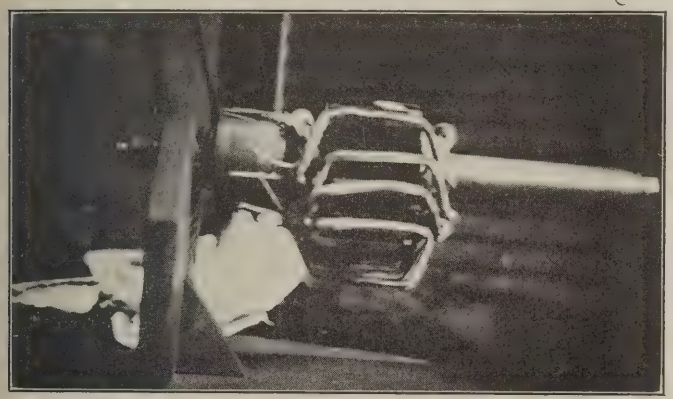


Fig. 1. Armature Resting in Winding Stand—The Right Hand Support Does Not Show in Photograph

personnel. All of the turbo-generator work for two divisions of average length is done at these shops under the methods here described.

The repair of these machines may be divided into two classes, the electrical repairs and the mechanical repairs. The electrical repairs including armature winding are done by two electricians, and the mechanical repairs, ex-

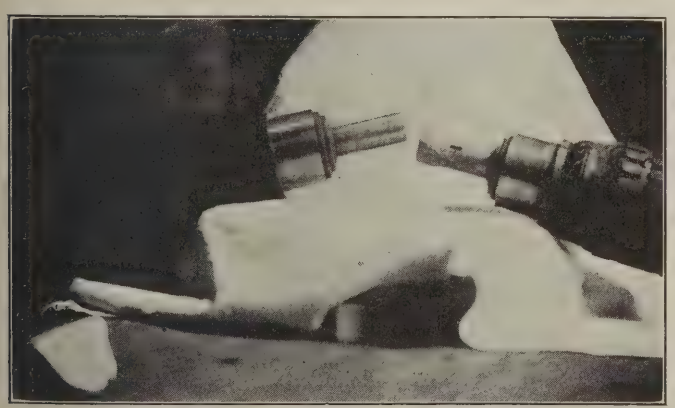


Fig. 2. The Shaft on the Right Has Just Been Welded While the Left Hand Shaft Shows How the Shaft Looks After Being Turned Down

cept welding, by a machinist, the latter spending but part time on this work.

Most of the machines coming into these shops are still equipped with the old type field and brake coils in which the series and shunt coils are separately wound and taped. There are but two repairs ordinarily performed on these coils—the soldering on of new terminals in cases where they have become loosened, and the more common repair of reinsulating the coil. The high operating temperature of these turbines causes the insulation on the coils to become brittle and break off in pieces. When this is the case all the old insulation is removed with a home made stripper not unlike a case knife; in fact, it is not unlikely that our stripper had its former home in the commissary. The coil is then retaped by hand with plain cotton tape, the first layer is not lapped, but the second layer which is wound in the opposite direction is half-lapped. The taped coils are then dipped in black baking varnish and after the surplus varnish has dripped off are baked in a steam heated oven which is used in common with the electrical and coach shops.

Although many shunt coils have come into the shop "open" it has not been found economical to repair them, unless the removal of the insulation shows the "open" to occur in the last few end turns, in which case new terminals are soldered on and the coil retaped and baked as

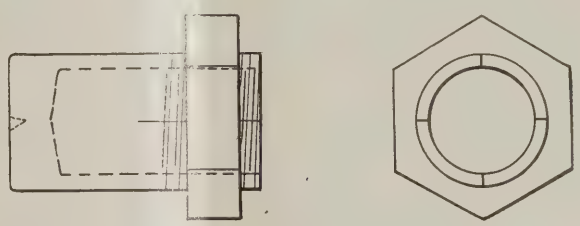


Fig. 3. Draw-Collars Used to Prevent End of Shaft from Spreading When Commutator is Being Turned

described. In the case of the shunt brake coil the taping must be very tight, as the clearance between the inner radius of the coil and the pole on which it fits is very small. The new coils supplied by the manufacturers are made with both windings under one tape so that they do not lend themselves so readily to easy repair, and but little attempt has been so far made to salvage those that have "gone up." Clogged drain valves sometimes permit the machines to become filled with condensed steam resulting in water soaked coils, in this case the coils are removed and dried in the oven referred to.

The armature is a plain lap winding of twenty slots and the same number of commutator segments. Purchased form wound coils are used, having a span of one to nine, and the leads from the coils are brought straight out from the slot to the segments. The armatures are banded by hand with the aid of a home-made tension device. The winding stand consists simply of two uprights at one corner of the bench, as shown in Fig. 1, although only one of the supports is seen in the illustration.

Both ends of the armature shaft are bored out and tapped for a ⅜-in. pipe expansion plug, the ends of the shaft being split to permit expansion into the inner bearing race. It has been found that the shaft sometimes slips in the inner race of the bearing, wearing down the

shaft, which, if not detected in time, will permit the armature to go "down on poles." These worn shaft ends are built up by the electric welder without previous turning or other preparation and turned to size. Fig. 2 shows a shaft just after having been welded and one after being turned up to size. The threads in the shaft end must usually be retapped after welding, but it took us quite a while to find out that many of our shafts wore down prematurely because the machinist was tapping the threads *before* resplitting the shaft end, in which case the tap having cut to its full depth, the expansion plug had very little chance to get in its work.

When turning commutators it was found that if a little pressure were exerted on the tailstock of the lathe that the shaft ends sometimes spread and put the shaft "out of true," so that draw-collars, as shown in Fig. 3, were made to slip over the shaft ends.

No attempt has been made at Stony Island to put new shrouds on the bucket wheels when they are ripped off, but brake discs are mounted and trued up with the aid of the fixture shown in Fig. 4. This fixture is simply an iron plate turned to fit the inside of the brake disc and the boss on top is to fit the bushing in the center of the bucket wheel. The holes at the edge of the plate are for

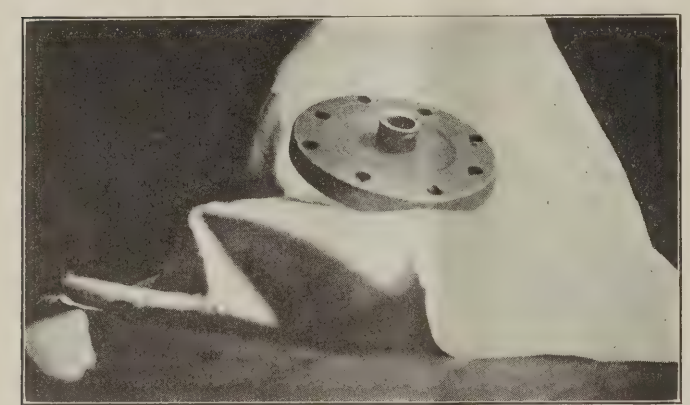


Fig. 4. Plate Used in Connection with Trueing up Brake Discs

locating the drill for the rivet holes in the disc. After being drilled the discs are riveted on the wheel and then trued on the lathe, mounted, of course, on an arbor.

Worn housings are bored out on the lathe and factory made bushings inserted in the arbor press.

Broken studs are bored out with an air drill and the holes hand-tapped for new studs.

When it becomes necessary to apply new gaskets to the separator chest both surfaces are scraped and a coating of plumbago applied, which very greatly facilitates the replacing of gaskets in the future. Practically no other repairs are found necessary to these turbines with the exception of the welding of broken parts, usually confined to legs of the machines which have been broken by rough handling.

Two 250-watt lamps in parallel are used as a testing load, and the turbines are air driven at a pressure of 120 to 140 pounds. As the air pressure from the compressor house averages only about 80 to 85 pounds an old air pump and tank from a scrapped engine have been rigged up to boost the pressure, as shown in Fig. 5. Normally when using air for cleaning or other purposes valves No. 2 and No. 3 are kept closed and valve No. 1 opened. But when the higher pressure necessary for testing is required valve No. 1 is closed and valves No. 2 and No. 3 are opened. This has been found a very inexpensive and satisfactory way to obtain the necessary testing pressure.

After the test of the machine the serial number, the extent and nature of the repairs, and the date are enterd in the card index. Later the disposition of the machine, whether it be sent to other shops, or applied to an engine in the back-shop or roundhouse as well as the number of such engine is added to the card, so that it is always pos-

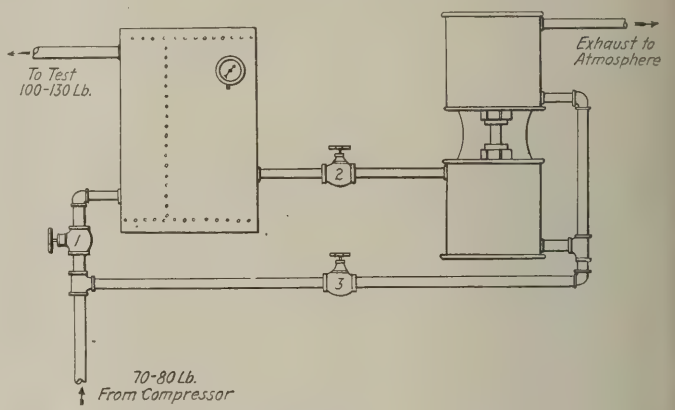


Fig. 5. Arrangement for Securing Higher Air Pressure for Testing Purposes

sible to tell just where any particular machine may be at any time, and when it was last in the shop and why.

With the exception of the welding and machining all this work is done in one 10 ft. by 15 ft. room in the electrical building, three other rooms of equal size being devoted to other electrical work.

Records kept over a two year period show that of all turbines entering the shop 84 per cent have not put in an appearance the second time, and this despite the fact that no repairs are made on turbines after being mounted on the locomotive.

Preliminary figures for April show United States exports of electrical material valued at $7,420,420, compared with $5,967,647 worth shipped during the same month of 1923.

An Electric Locomotive on the Victorian Railways

Elementary Theory of Alternating Currents

A Series of Practical Articles Explaining a Difficult Subject in a Simple Manner

By K. C. Graham

Part III

THE study of alternating currents is somewhat more complicated than that of direct currents because of two things that do not, ordinarily, have any bearing on the limitation of flow of direct current, but which virtually form a hedge of restrictions around the flow of alternating current. These two things are known as *inductance* and *capacity,* and because of their importance we shall study them in some detail.

Inductance

Inductance has been rightfully termed electrical inertia because it acts toward the flow of an electrical current in

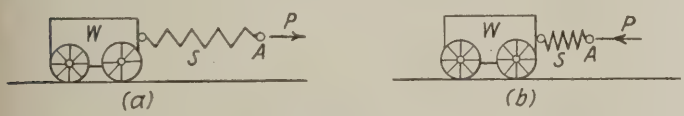


Fig. 21

the same way that inertia acts toward the production of mechanical motion. Thus, if we wish to start a ball rolling we must exert pressure to overcome the inertia of the matter of which the ball is composed before it will start to move. After it has been put in motion we must exert pressure to bring it to rest, or in other words we must overcome its inertia. Inertia is defined as that property which tends to cause matter at rest to remain at rest and matter in motion to remain in motion. The important thing to notice here is that the pressure must be applied *before* the desired result begins to approach accomplishment. This will be more readily grasped by means of another mechanical analogy as in Fig. 21.

In view (a) W represents a wagon connected to some

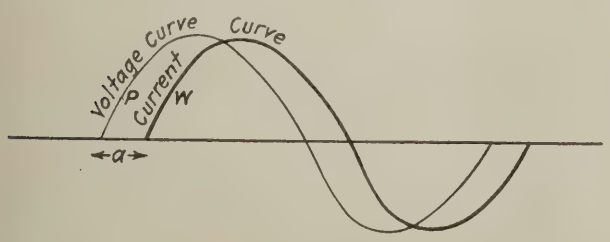


Fig. 22

means of motive power P by spring S. If it is desired to move W the spring must be stretched to a certain extent before W will start to move. Again when it is desired to bring W to rest it will not stop the instant that the force P ceases to act, but W will continue to move for a small interval until the spring is compressed to such an extent that the back pressure exerted by it overcomes the tendency of W to continue in motion. Thus if W is a trailer attached to automobile P by means of the spring the automobile will start to move before the trailer because of the stretch of the spring and the trailer will continue to move after the automobile has come to rest, until the pressure of the compressed spring is equal to the inertia of the trailer. Therefore we may say that the motion of W lags behind the force P. This is clearly illustrated in Fig. 22 where curve P represents the force P and curve W represents the force W, the distance (a) being that distance through which P acts before W starts to move. This is analogous to the condition in an electric circuit where inductance is present. If P represents the voltage of the circuit (pressure) then the flow of current through the circuit which lags behind the impressed voltage, may be represented by W, the distance (a) representing the angle that the conductor will move through before the voltage generated at any certain position of the conductor is effective in forcing current through the circuit. This will be made clear by reference to Fig. 23.

Here a conductor is shown in two positions, opposite the center of the pole and again, at a distance of angle (a) from this position. Due to the inductance present in the

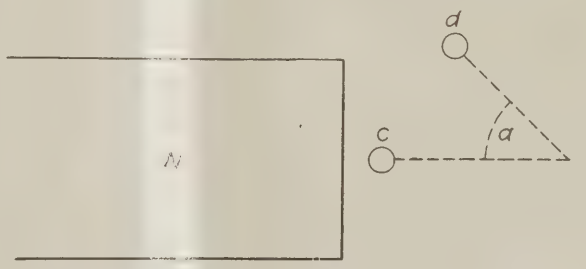


Fig. 23

circuit the maximum value of the current will not occur at the position of maximum voltage which is at c, but will occur when the conductor has reached position d even though the voltage generated at this position is less than that at position c.

While it would be very difficult for one to attempt to explain just why a body has mechanical inertia it is not nearly so hard to give a clear understanding of the reason for electrical inertia or inductance.

In Fig. 24 (a) when the loop is passed across the face of the magnet a voltage is generated or induced in it and a current will flow if the loop forms a closed circuit as at x. This is known as generator action in contrast to the straight induction methods, which we shall take up, but it may be said that all forms of electrical induction are fundamentally the result of this generator action. This will be clarified by reference to view (b).

Here battery Z supplies current to loop M when key K is depressed so as to close the circuit. Adjacent to the circuit is a closed loop L. When current starts to flow through M the lines of force spread out from the wire and cut across the near side of loop L, the lines moving in the direction indicated by the arrow (outward from the con-

ductor, thereby generating a voltage in L and causing a current to flow through it as shown by the arrowhead. When the battery current attains a steady value the lines cease to move, that is, they stop moving outward from M and hold the positions they have attained. Consequently the current in L ceases. However when the key is released the current in M decreases and the lines of force recede toward M thereby again cutting across L as in view (c) and inducing a voltage in L that is the opposite in direction from what it was when the current was increasing in M. Thus a current was made to flow in loop L without there being any connection between it and the circuit containing the source of power. This is a form of straight induction, being technically known as mutual induction because it represents induction between two separate circuits, each circuit acting on the other. This is strictly true because it may be shown that the lines emanating from L due to the current induced in it, react on M in the same way, but in a lesser degree. However this feature is not essential at this point. This leads us to the more common form of induction—self induction. As the name implies, it refers to the study of the effect of a changing current on the flow of current through the conductor itself.

When the current starts to flow through the conductor the lines of force spread out from the center of the wire and cut the outer layers of the material of which the wire is composed so that a voltage is generated in the wire.

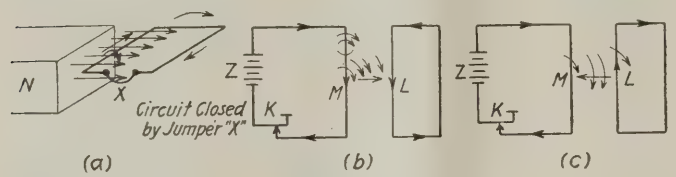


Fig. 24

The direction that a current would tend to flow if this voltage became active would be opposite to that in which the current is flowing and this voltage, therefore, opposes that of the battery, as shown by dotted arrow in Fig. 25 (a). This tends to delay the building up of the current so that it does not instantly attain is maximum value, but gradually overcomes the opposing force until it has reached the maximum point whereupon the magnetic field surrounding the wire becomes constant or steady; the lines cease to cut across the conductor and the opposing force becomes zero.

The instant we start to break the circuit at key K the current starts to decrease so that the magnetic lines contract toward the center of the conductor, thereby cutting across the outer layers of the conductor and generating a voltage opposite from that in the case where the current was increasing. This voltage, as shown by the dotted arrows in view (b), tends to assist the main voltage in maintaining current through the circuit so that the current would not instantly fall to zero. It is this feature that causes the arc when an electrical circuit is broken. Thus it is seen that electrical inertia is comparatively easy to explain. It should be particularly noted that the current lags behind the voltage—as in the current-voltage curve of Fig. 22. The effect of the presence of iron in or near the circuit is to increase the inductance of the circuit because of the fact that a given value of ampere-turns will produce a greater value of magnetic flux in iron than in air due to the greater conducting power that iron exhibits toward magnetic lines. This larger value of flux induces a greater counter voltage in the conductor thereby increasing the inductive effect noted above. The unit of inductance is the *henry*. A circuit is said to have an inductance of one henry when a current change of one ampere per second induces a pressure (counter voltage) of one volt. Thus in the circuit described, if the current increased from zero to one ampere in one second and the counter voltage was equal to one volt then this circuit would be said to have an inductance of one henry. Although as previously mentioned inductance does not receive

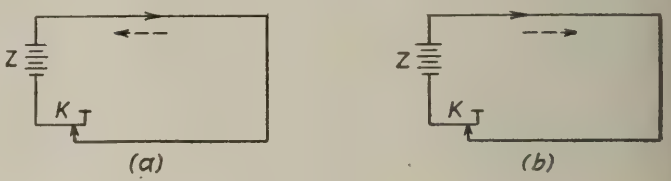


Fig. 25

much consideration in connection with the direct currents because of their unchanging nature, it is one of the most important subjects connected with the study of alternating currents because of their constantly changing nature. Thus when the frequency of the circuit is 60 cycles so that the current is alternating 120 times per second the inductance of the circuit will have to be overcome 120 times when the current is increasing and the same number of times when the current is decreasing, a total of 240 times that the inductance must be overcome in one second so that it is readily apparent why inductance plays such an important part in connection with alternating currents.

Capacity

Capacity is a blood brother of inductance as regards its importance in connection with alternating currents although it plays a lesser part in the average circuit. Its effect is the exact opposite of that of inductance. This will be made more clear by reference to a mechanical analogy, Fig. 26.

This is nothing more or less than the wagon and the

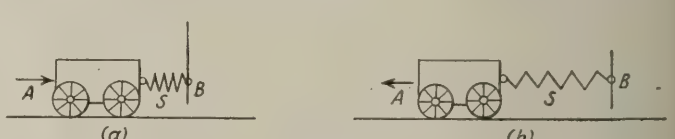


Fig. 26.

spring which we used to illustrate inductance in connection with Fig. 21. The manner in which the force is applied to the wagon is, however, much different than in the previous illustration. Here the spring is fastened to an immovable object such as wall B, and force is applied to the wagon so that the spring is compressed between it and the wall. Suppose that the spring is compressed and that we desire to move the wagon away from the wall. The instant the pressure toward the wall is removed the wagon starts to move outward because of the stored up energy in the spring. After the wagon has been pulled outward a certain distance the spring will have become stretched so that when the pulling force becomes zero it will tend to pull the wagon toward the wall before the force, that is to accomplish this purpose, begins to act.

This is represented by the current-voltage curve of Fig. 27 where the current is seen to lead the voltage. The movement of the wagon is the current and the pressure applied is the voltage as in the case of the inductance illustration, but the spring, in this case, represents the capacity. While capacity is a form of electrical inertia its cause can not be explained in quite the same way as was inductance.

Fig. 28 shows generator *G* connected to condenser *C* which consists of two sets of metal plates separated by a thin layer of some non-conducting substance such as air or

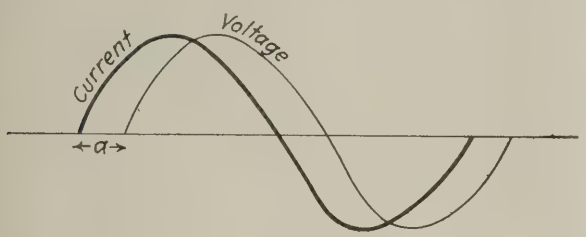


Fig. 27

paper, there being no electrical connection between the two sets of plates. When the generator is operating a current will flow through the circuit, however, notwithstanding the fact that the plates are separated by the non-conducting material. This may be explained by assuming that the separating material becomes conducting after a certain application of force. Due to the passage of this current the air or other medium between the plates is stressed or strained so that when the voltage across the terminals tends to decrease a current will tend to flow out of the condenser to the generator. This is no doubt brought about in much the same way that the voltage is induced in the inductive circuit previously studied. While the current flows through the condenser a voltage is gradually built up in it so that when the generator voltage begins to decrease during the second half of the alternation, the condenser will try to discharge. As the value of the voltage becomes lower it will become less than that of the condenser and the condenser will send a current through the circuit in the opposite direction.

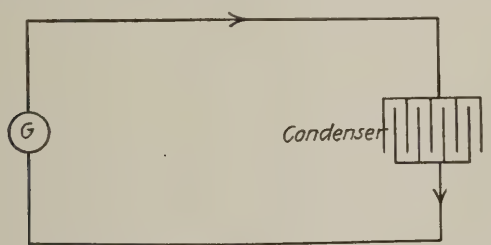


Fig. 28

Fig. 29 (a) shows current flowing through the circuit in the direction shown by the *A* arrows. The *B* arrows designate the direction in which the voltage is building up in the condenser. View (b) shows the condition at the instant the voltage of the generator becomes less than that of the condenser. View (c) shows the generator voltage reversed, during the second half of the cycle, and view (d) shows the voltage building up in the condenser as in (a), but in the opposite direction. This has the effect of causing the current to precede the voltage as in Fig. 27. The reason that a condenser was used by way of illustration is that capacity effect is always the result of condenser action between two parts of the circuit. Thus on a two wire transmission line each of the wires act as a plate and the air acts as the separating medium. On a one wire line the wire acts as one plate and the ground as the other. As previously mentioned, capacity is opposite in effect from inductance and may be used to neutralize the effect of inductance. The unit of

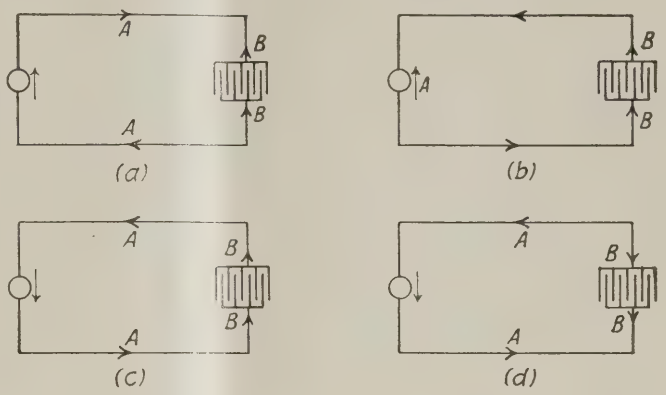
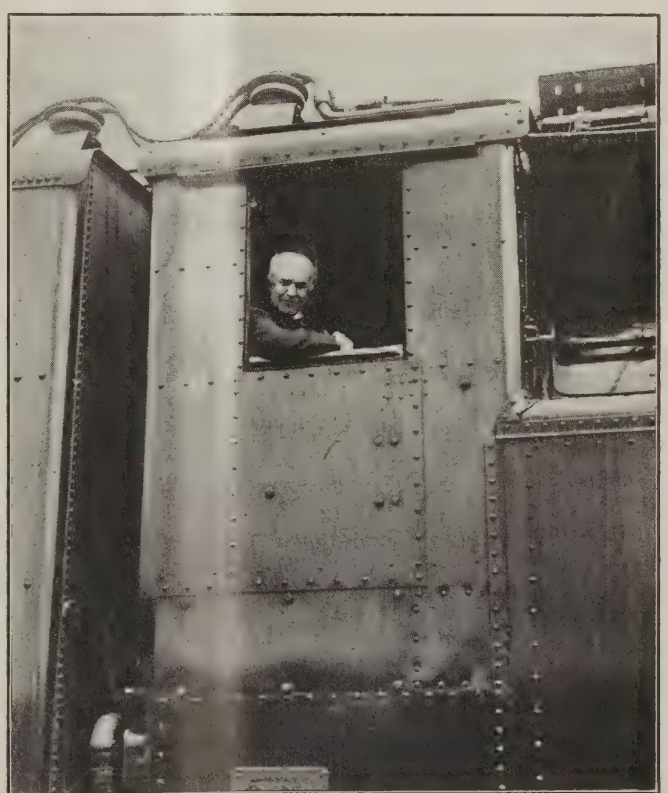


Fig. 29

capacity is the farad and a condenser may be said to have a capacity of one farad when a current of one ampere flowing through it for one second produces a pressure of one volt between its terminals.

It should be noted, in passing, that the presence of iron does not have any marked effect on the capacity of the circuit as it has on the inductance of the circuit so that we conclude that the flux due to capacity is somewhat different from that of magnetism and we may assume that that there are really two different kinds of fluxes—magnetic and capacitive.



International Newsreel Photo

Thomas A. Edison Inspects New Locomotive for C. M. & St. P. at Pennsylvania Yards, Newark, N. J.

Roundhouse Lighting on the Elgin, Joliet & Eastern

All Conduit for Lighting Placed in Concrete Pillars or Floor—Single Lead Covered Conductor for Welding Distribution

By A. W. Ryan
Chief Electrician, Elgin, Joliet & Eastern Ry., Joliet, Ill.

THE Elgin, Joliet & Eastern has recently completed the construction of two concrete roundhouses, a 22-stall house at Joliet, Ill., and a 24-stall house at Gary, Ind. These roundhouses are lighted with reflector units mounted on the wall 10 ft. 6 in. from the floor. There are two units in the front wall for each stall and one unit at the rear on the pillar between the doors.

The brackets and supports for the lamp units are shown in detail in Fig. 1. Two pieces of 2 in. by 3 in. angle iron ½ in. thick were set with 8 in. embedded in the concrete wall and 18 in. extending out. A cross piece of 2 in. angle iron 6 ft. long is bolted to the supports and the lamp units are placed on adjustable brackets on the ends of the cross member thus spacing the lamps at 6 ft. centers. The single units at the rear of the stall are mounted on an adjustable bracket bolted to a single 2 in. by 3 in. piece of angle iron which is embedded in the concrete 9 ft. above the floor on the post between the doors. Fig. 2 shows the respective location of the units in the entire house. Figs. 3 and 4 are pictures of the lighting units in service. Fig. 5 shows conduit arrangement laid in concrete.

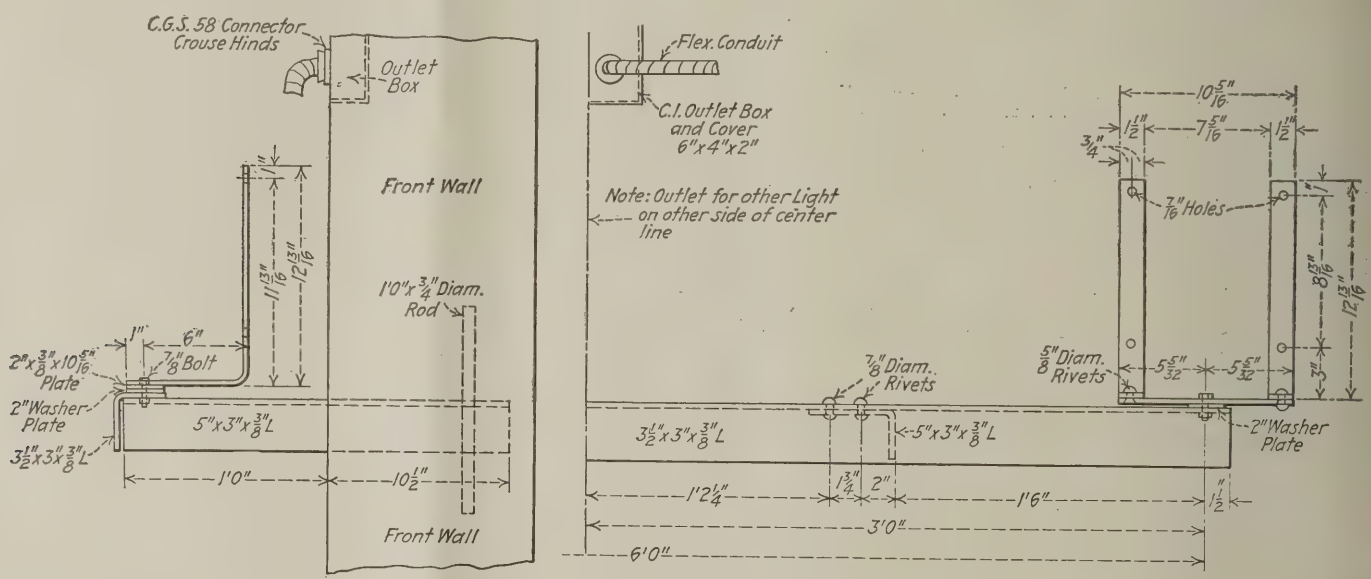


Fig. 1—Details of Flood Lighting Bracket

These lighting units are the Electric Service Supply Company's No. RW 918, consisting of a cast iron case with hinged front glass cover. The metal ring of the cover is held tight with a thumb screw so as to make the unit dust proof. A 9 in. prismatic glass reflector with a focal length of 4½ inches throws a wide beam of light yet eliminates a direct glare. A 200-watt, 110-volt mazda lamp is used in each unit. The proper illumination of the

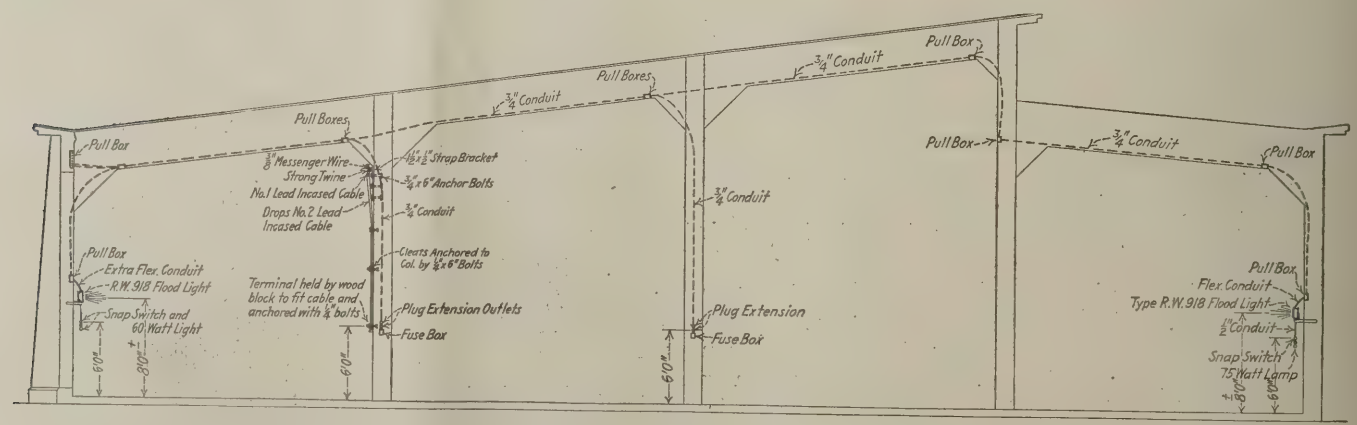


Fig. 2—Elevation of Roundhouse Showing Arrangement of Conduit, Fittings and Lighting Fixtures

house depends a great deal on the height at which these lamp units are mounted and the ability to rotate the lamp in either direction and tighten the adjustment to stay. These requirements are taken care of in the style of

Fig. 3—Single Light Unit Together with Reading Lamp Mounted on Pillar Between Doors

bracket shown which was designed and built by the E. J. & E. forces.

At each alternate set of lighting units in the front of the house and at every unit at the rear, there is a vapor glass enclosed lighting unit, Crouse Hinds VA-189, suspended by a conduit at a point 5 ft. 6 in. from the floor. These lights are for illuminating the passage way and for the reading of reports, etc. Complete assembled units are shown in the pictures. The reading lamps in the front of the house are 75 watt and those in the rear are 50 watt.

Each lighting unit together with the reading lamp, if one is attached, is controlled by a cast-iron enclosed snap-switch suspended on conduit beneath the unit as shown. The units are connected by ¾ in. extra flexible conduit to an outlet box on the wall.

Conduit Placed in Concrete

All conduit was embedded in the concrete pillars, floors or roofs during construction. Three-quarter inch enameled conduit was used throughout and no ¾ in. contains over two circuits. All turn boxes and pull boxes in the concrete are of cast iron. The feed circuit for each set of lamps is on a separate 2-wire circuit of No. 12 double rubber covered copper wire. The circuits are all fed from a single cabinet centrally located and containing a pair of fuses for each circuit. The 110-volt feed to this cabinet comes through a two pole enclosed type switch operated by an external handle so arranged that the door to the fuse compartment cannot be opened unless the switch is open. This panel, the main switch and a set of lighting units is shown in Fig. 4.

Some of the advantages of the new system of lighting are that one man can clean and replace burnt out globes, whereas with the overhead lighting system it requires two men to clean reflectors and replace burnt out globes, as one man is required to hold step ladder. On the new lighting system the one man has a portable safety ladder which hooks to the light bracket.

As the electric lamps are enclosed on the lighting units the theft of bulbs is reduced to a minimum. It has been the experience of the E. J. & E. that where lamps are subjected to smoke and steam such as in a roundhouse,

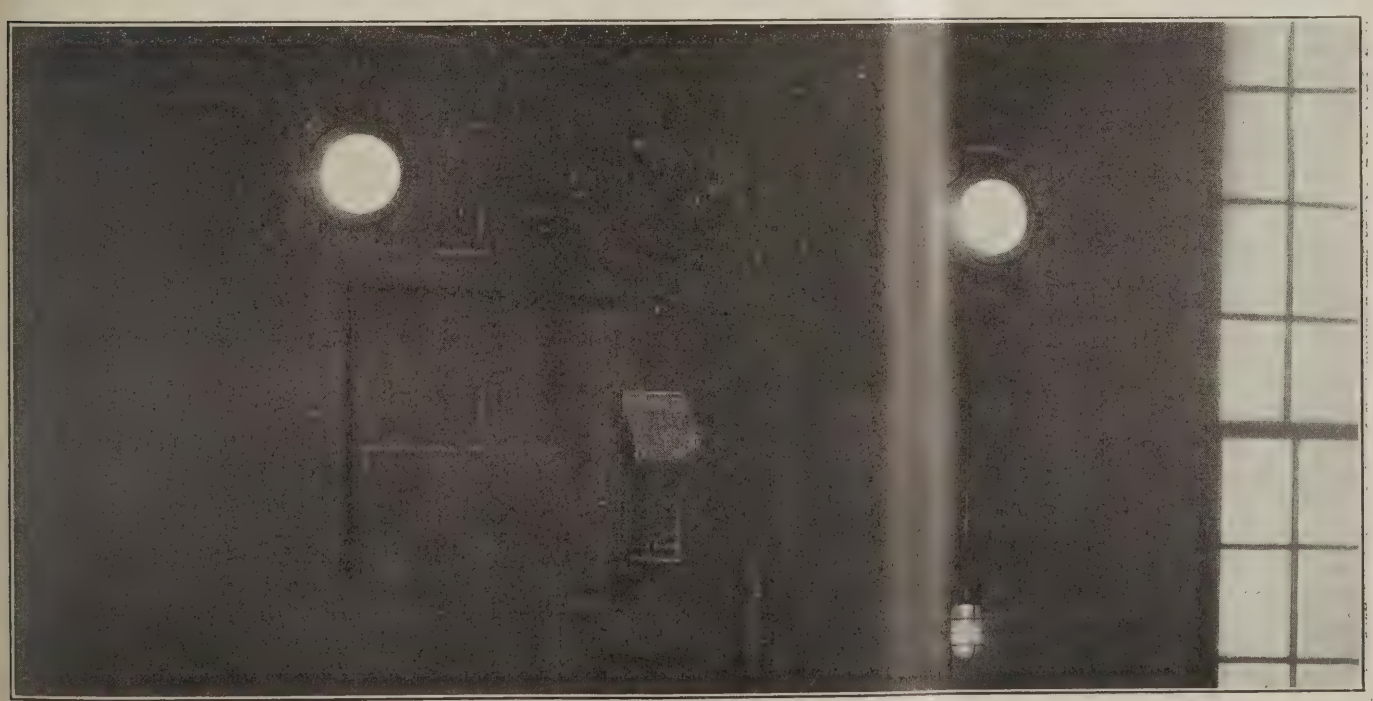


Fig. 4—Double Light Unit Mounted on Front Wall Between Each Stall and Supported by the Specially Designed Bracket Shown in Fig. 1

that the life of the lamp is short as compared with an enclosed unit. The lighting has been in service for three months and the roundhouse, foremen and mechanical officers are well pleased with the illumination given.

Portable extension line outlet units, Hubbell type 5624, are mounted on the two front posts of every other stall.

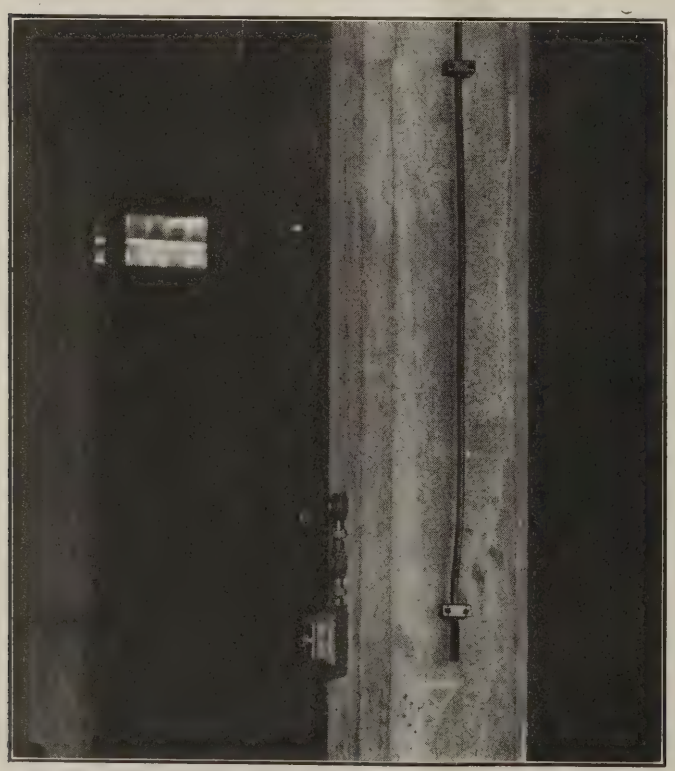


Fig. 6—Extension Outlets, with Fuse Box on Side of Pillar, Welding Cable and Connection on Front of Pillar

The two fuses for such a set of outlets are mounted inside a cast iron box just beneath the outlet, see Fig. 6. In this way a cross in an extension line will blow the local fuse and cause no disturbance on any other circuit. The extension circuits are fed from a separate switch located about 50 ft. from the lighting cabinet so as to cause no confusion.

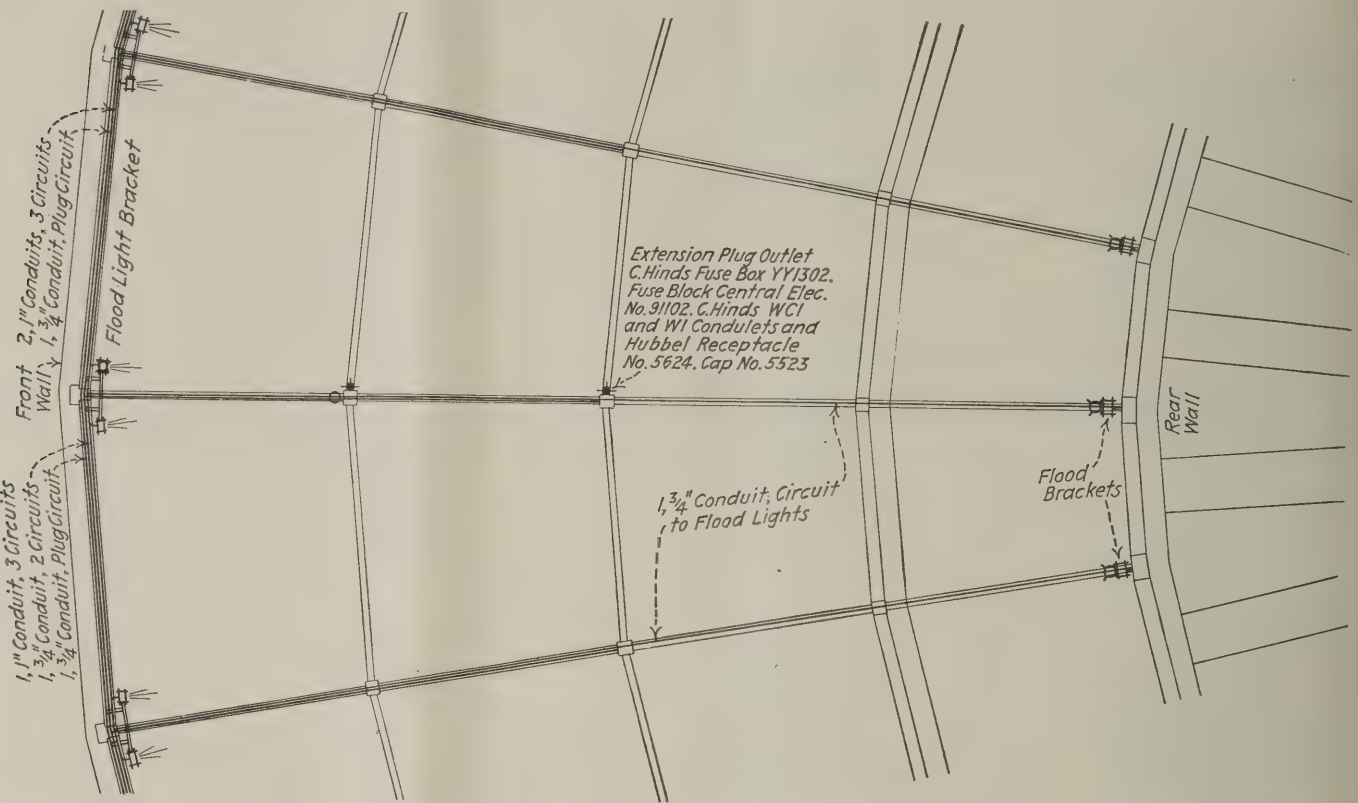

Flood Light Bracket
Front Wall
2, 1" Conduits, 3 Circuits
1, 3/4" Conduit, Plug Circuit
1, 1" Conduit, 3 Circuits
1, 3/4" Conduit, 2 Circuits
1, 3/4" Conduit, Plug Circuit
Extension Plug Outlet C. Hinds Fuse Box YY1302. Fuse Block Central Elec. No. 91102. C. Hinds WC1 and W1 Condulets and Hubbel Receptacle No. 5624. Cap No. 5523
1, 3/4" Conduit, Circuit to Flood Lights
Flood Brackets
Rear Wall

Fig. 5—Section of Roundhouse Showing Two Stalls with Arrangement of Conduit and Lighting

Electric Welding Circuits

An electric welding machine with a 220-volt, 25 hp. motor and a 60 to 70 volt, 600 amp. generator is located in the fan house, overhead near the center of the roundhouse. The negative side of the welding circuits is grounded to rails in roundhouse, and a single conductor distribution is used. For the main run this conductor is a No. 3/0 single conductor lead-covered cable, while for the drops on the front post of every other stall the conductor is a No. 2/0 terminating in a threaded terminal as shown in Fig. 6. The main feed lead-covered conductor is suspended from a messenger attached to strap iron brackets along the girder of the roof while the drops are held by porcelain cleats. With a capacity of 600 amp. two operators can weld or one operator can cut and another weld at the same time, which is considered sufficient capacity for normal demands.

Most of the telephones in use in Argentina are of English and American manufacture. The service is concentrated in the Provinces of Buenos Aires, Santa Fe, Cordoba, Entre Rios, Corrientes, Tucuman, and the Territory of La Pampa. There are 30,250 kilometers of general service line within the borders of Argentina, which, when added to the 640,150 kilometers used as private and railway lines, brings the grand total for the Republic to 670,150.

The Development of the Electric Locomotive

A World-Wide Summary of Present Day Practice as Regards Heavy Electric Traction

By F. H. Shepard
Director of Heavy Traction, Westinghouse Elec. & Mfg. Co.

ELECTRICITY wherever used has led to improvement in methods, sometimes revolutionary; witness, illumination, urban and suburban traction, machine shop practice as well as certain of the metallurgical and chemical industries. The natural suggestion for railroad electrification has therefore been appealing and the subject of much popular discussion; but, notwithstanding the first real use of electric locomotives, which was in the Baltimore and Ohio Tunnel at Baltimore in 1895, the world have accomplished much in development and progress, especially toward indication of values for future transportation needs.

The consideration for a more extended application to the various classes and conditions of railroad operation and to their modification and improvement has not been as great as indicated results and advantages, immediate and future, when analyzed, would seem to have warranted. This is essentially due to the difficulty in securing funds

TABLE I - SUMMARY
APPROXIMATE SURVEY OF ELECTRIC LOCOMOTIVES - BUILT AND BUILDING 1924

	D.C. HIGH VOLTAGE						A.C. SINGLE PHASE				
	No.	Aggregate Wt. Thousands of Pounds	Aggregate Horsepower (One-Hour)	Lb. Per H.P.	Average Wt. Per Locomotive		No.	Aggregate Wt. Thousands of Pounds	Aggregate Horsepower (One-Hour)	Lb. Per H.P.	Average Wt. Per Locomotive
Brazil	21	4,196	31,060	135	200 M.Lb.						
Canada	6	996	7,680	130	166		6	792	4,500	176	132 M.Lb.
Chile	42	8,446	68,420	124	201						
Mexico	10	3,090	27,360	113	309						
United States	131	37,863	247,300	153	289		199	57,845	359,450	161	290
Total American	210	54,591	381,820	143	260		205	58,637	363,950	161	286
Austria							84	12,259	99,250	124	146
England	11	1,898	12,800	148	173						
France	336	53,805	538,300	100	160						
Germany							290	61,029	486,054	126	210
Norway and Sweden							136	25,570	153,860	166	188
Spain	12	2,220	19,320	115	185						
Switzerland							207	43,514	371,980	117	211
Total European	359	57,923	570,420	102	162		717	142,377	1,111,144	128	199
Japan	42	5,942	55,420	107	142						
Java	6	840	8,300	101	140						
New Zealand	5	537	3,400	158	107						
South Africa	78	11,400	93,700	122	146						
Total Other Countries	131	18,719	160,820	117	143						
Totals	700	131,233	1,113,060	118	188		922	201,009	1,475,094	137	218
	D.C. LOW VOLTAGE						A.C. THREE PHASE				
Argentina	2	295	1,840	160	148 M.Lb.						
United States	128	31,815	261,090	122	248		4	920	6,000	153	230 M.Lb.
Total American	130	32,110	262,930	122	247		4	920	6,000	153	230
Italy	10	1,520	13,600	112	152		492	76,580	1,197,730	64	156
Switzerland							6	913	9,369	98	152
Total European	10	1,520	13,600	112	152		498	77,493	1,207,099	64	156
Totals	140	33,630	276,530	122	240		502	78,410	1,213,100	65	156
Grand Total D.C.	840	164,863	1,389,590	119	197	Grand Totals A.C.	1424	279,419	2,688,194	104	196

growth of railway electrification in America has been relatively slow.

The reasons therefor may be taken as

1st. The relatively high capital expenditure required and the recent difficulties of railroad finance.

2nd. The plentiful supply and the relatively low cost of coal.

3rd. The lack of general understanding or definition of objectives for future railroad service.

Electrifications to date have generally, in most countries, been made to meet some abnormal situation, local condition or local restriction, which required special consideration. In all these cases, the special object has not only been attained but the service has been markedly improved over that of the steam service replaced. Even with these limitations, electrifications throughout the which has halted all major railroad improvements during recent years. For the immediate future, great and exactly calculable economies are too often the sole requisite and, owing to the difficulty of evaluation, little consideration is given to the less tangible immediate advantages and to those relating to development of position for future requirements and growth.

Such requirement for immediate financial advantage does not generally govern when consideration is given to track revision or additions, enlargement or modification of terminals, additions to shops, equipment and many other desirable programs which come under the general heading "Additions and Betterments of Property," but it appears that when electrification is considered, too often conditions of the moment or of the immediate future are those which control. Where in the accomplishment of

great progress or in the development of great strength or position in any industry has so limited a view prevailed?

The United States with its great distances, is what it is because of Rail Transportation and its position in the future will depend upon Rail Transportation.

It is coming to be accepted more and more that the future role of the railroads will be that of wholesalers of transportation. This means the mass movement of traffic. With such mass movement will come ordered or scheduled movement, thereby obtaining greater use of equipment and facilities, higher speeds, larger trains, and greater despatch through terminals. It is hard to see how the continued growth and prosperity of industry in America can otherwise be obtained.

Electricity, due to its economy and future universality of generation, its ease of distribution and the flexibility of its control and use, is the outstanding agency through which this result will be secured. Instead of employing distributed generation of power to transport and move trains by the many small steam units with their great limitations in capacity (hence, in their speed, tractive effort and acceleration) electrification permits the centralization of power generation with absence of such limitation to capacity and no such limitations to tractive effort, speed and acceleration. Furthermore, there is the advantage that the power can be instantly available when and where most needed, over a great range of distance within economical transmission, and, when not needed, is shut off without continued standby losses. Electrification is coming to be realized more and more as the tool for such transportation service. Compared with the past, it may be predicted that more generally in the near future and always in the long future its consideration for Additions and Betterments of Property will obtain.

The electric locomotive can be one of relatively unlimited capacity as to tractive effort or speed, or both. It can, for this reason, haul more tons over a given distance in less time than a steam locomotive, but, in addition, it will also be available for a much greater period of time, for experience has shown the possibility of obtaining a serviceability factor approaching 90%.

The foregoing has been conclusively demonstrated by experience with such locomotives as have been built since and including the first pioneer installation at the Baltimore and Ohio Tunnel, and this irrespective of application, of type, or the electrical or mechanical system used.

There are at present in existence or under construction, over 2,200 electric locomotive units, aggregating some 4,000,000 horsepower, for every class of service excluding those which may not readily be classed as main line locomotives. Table I shows their distribution, nominal horsepower, capacity, their weight and the electric system used.

TABLE II

RAILWAY ELECTRIFICATION SYSTEMS

SYSTEM	PRIMARY		SECONDARY		LOCOMOTIVE
	Generation	Transmission	Conversion	Distribution and Contact	
Low Voltage D. C.	Heat or Hydro.....	3 phase at commercial or low frequency....	At substations. Transformers and rotary converter or M. G. set or rectifier.....	Heavy feeder and single overhead wire or Feeders and third rail....	Low voltage D. C. motors
High Voltage D. C.	Heat or Hydro....	3 phase at commercial or low frequency....	At substations. Transformers and M. G. set or rotary converter or rectifier.....	Heavy feeder and single overhead wire.....	High voltage D. C. motors M. G. set for auxiliaries.
Three Phase.....	Heat or Hydro....	3 phase at low frequency....	At substations. Transformer.....	Feeder and two separate overhead wires.....	High voltage 3 phase induction motors.
Single Phase.....	Heat or Hydro....	3 phase at commercial frequency.....	At receiving station. Frequency changer or phase balancer; and At substations. Transformer.....	Small or no feeder and single overhead contact wire.....	Low voltage 3 phase induction motors with phase converter and transformer or Low voltage single phase motors and transformer or Low voltage D. C. motors with M. G. set or rectifier and transformer.
		Single phase at low frequency	At substations. Transformer.....		

It will be noted that of the aggregate number and horsepower—

6.2%	in number and	6.7%	in horsepower are	low	voltage	d. c.
31.0%	" " "	27.3%	" " "	high	"	" "
40.6%	" " "	36.2%	" " "	single	phase	a. c.
22.2%	" " "	29.8%	" " "	three	"	" "

Of the high voltage d. c. locomotives, 18.7% are in the United States and 48% are in France.

Of the single phase locomotive, 21.6% are in the United States, the remainder being in continental Europe.

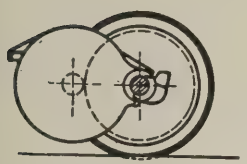
Of the three phase locomotives, 98% are in Italy.

The permissible length of this paper precludes the possibility of description in detail of the development of the electric locomotive. The steam locomotive during its career, a century long, has in general broadly followed along its original lines of design, necessarily so by rea-

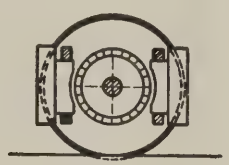
son of its very nature. The main and controlling element of a steam locomotive is its boiler and around it is designed the attachment and grouping of cylinders, frames, running gear and the other elements. The reason for this is that a steam locomotive generates its own power and in addition to being an engine for developing drawbar pull, it carries its own power plant. It is, therefore, circumscribed as to size and restricted as to wheel arrangement, placement of cylinders and general configuration. The electric locomotive, on the other hand, does not generate its own power. It is only an engine for developing drawbar pull which transforms or converts external power. Its tractive effort originates at its motor or motors and by the mechanical connecting devices is transmitted to the drivers. The other equipment is merely adjacent to the motors and may be carried by the locomotive frames or cab structure or by both. There may be any number of driving motors, large or small, all under common control. It is possible to design an electric locomotive around any one of its elements and with major variations almost without limit. This great latitude with which design can be accomplished secures many advantages but likewise imposes the difficulty of decision as to the best amongst the various types.

It will be seen that steam locomotives have a common resemblance to each other and permit of comparatively

TABLE IIIA
TYPES OF DRIVE
Individual Drives

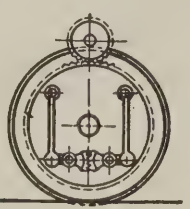


(a) Axle hung nose suspended motors single reduction, solid or flexible, single or twin gears.

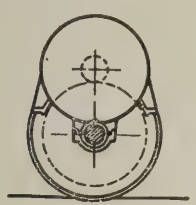


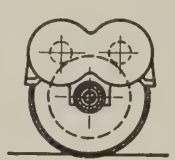
(b) Direct gearless drive with the armature mounted upon and integral with the axle; the motor field integral with the locomotive frame.

(c) Direct gearless quill drive, the armature mounted on a quill surrounding the axle, the connection to wheels through spring elements, permitting relative vertical movement; motor field mounted on locomotive main or truck frame.



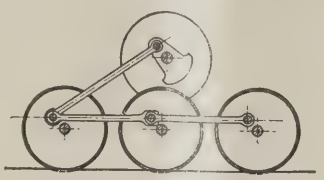
(e) Geared flexible drive with motors frame-mounted, with or without quill gear connection through a flexible universal driven wheel, to permit relative vertical movement between motor and axle.



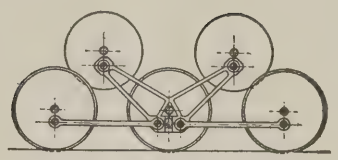


(d) Geared quill drive, the motors and quill frame-mounted; the quill surrounding the axle carrying the gear, connection to the driven axle through springs or mechanically flexible elements, these permitting relative vertical movement between motor and axle.

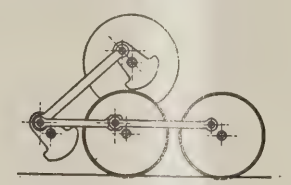
TABLE IIIB
TYPES OF DRIVE
Collective Drives



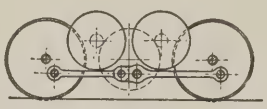
(f) Direct side rod drive by which the torque is transmitted from the motor shaft by direct rod connection to the driving wheels.



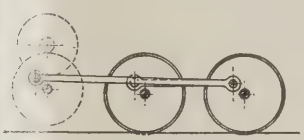
(g) Direct drive with Scotch yoke by which the transmission of torque to wheels is effected directly from the motor or motors, arranged to permit independent vertical movement of the driving pin and bushing.



(h) Jack shaft side rod drive by which the torque is transmitted from the crank of one or two motor shafts through a main rod or rods to a jack or auxiliary shaft or shafts, and from the latter to the wheels through side rods. The connection from jack shaft to side rods may be direct, or by yoke, with or without flexible element.



(i-1) Geared jack shaft side rod drive by which the torque from the motor shaft is transmitted to the jack shaft by solid or flexible gears and from the jack shaft to wheels by side rods direct or by yoke.



(i-2) Geared jack shaft side rod drive similar to (i-1) except that the jack shaft is outside the driving wheels.

Figure I

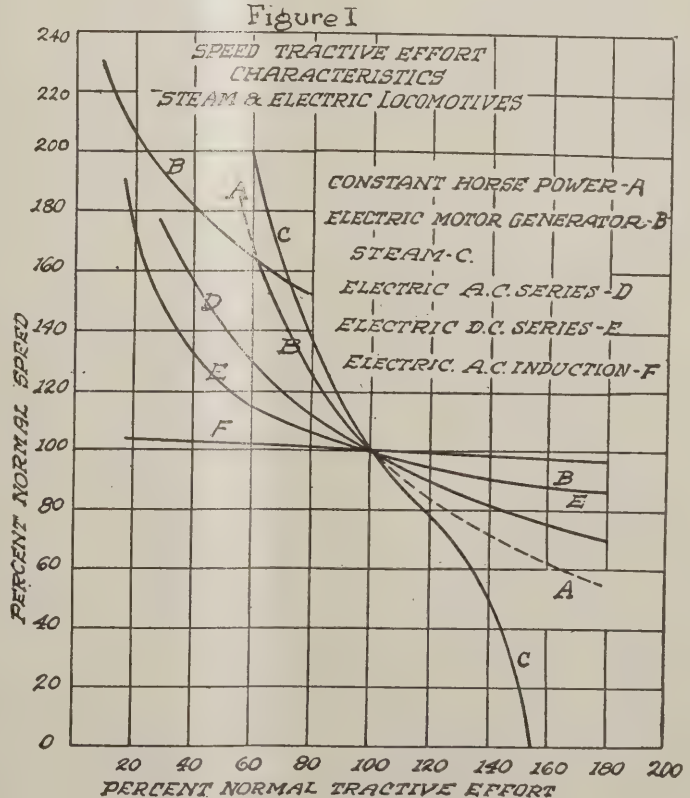


Table IV A. Direct-Current Locomotives

Continent	Country	Railway	Key No	Contact Line: Volts	Contact Line: Type	Gauge Inches	Year in Service	Number	Type of Serv	Axle Classification	Methods of Drive	Dimensions-Inches: Wheel Diam. Driver	Dimensions-Inches: Wheel Diam. Idler	Dimensions-Inches: Lgth over all	Dimensions-Inches: Rigid Wheel Base	Weights Thousands of Pounds: Total	Weights Thousands of Pounds: On Drivers	Weights Thousands of Pounds: Per Driving Axle	Weights Thousands of Pounds: Mech Parts	Weights Thousands of Pounds: Elec Parts	One Hour Rating: HP	One Hour Rating: MPH	One Hour Rating: TE Lbs/1000	One Hour Rating: Wt per HP	Continuous Rating: HP	Continuous Rating: MPH	Continuous Rating: TE Lbs/1000	Continuous Rating: Wt per HP	Max Safe Speed MPH	Motors: No.	Motors: Volts	Motors: Ventilation	Motors: Gear Ratio	Road No.	Wheel Arrangement	Cab	Key No
America	Argentina	Buenos Aires & Western	1	800	Both	66	1916	2	Fr't	B-B	Gear	48	—	518	108	147.4	147.4	36.9	96.9	30.5	920*	18	19.2	160	528	24.6	8.1	280	46.7	4	775	F	18.70				1
	Brazil	Paulista	2a	3000	Line	63	1921	2	Pass	1B+B1	Quill Gear	63	36	635	100	283.8	206	51.45	166.8	117	2400	42.8	209.6	118	1800	47.2	14.2	158	65	4 Twin	3000	F	28.86	212-3			2a
			2b	3000	Line	63	1921	2	Fr't	C+C	Flex Gear	40	—	602	168	234*	234	39.05	145.45	88.85	1800	20.8	32.4	130	1350	23.4	21.6	173	42	6	1500	F	16.83	214-5			2b
			2c	3000	Line	63	1921	4	Pass	2B+B2	Twin Gear Flex	42	36	660	93	240	160	40.0	158.9	81.1	1680	40.5	156.8	143	1600	41.2	14.7	150	62	4	1500	S	30.70	200-3			2c
			2d	3000	Line	63	1921	8	Fr't	B+B	Twin Gear Flex	42	—	470	104	200	200	50.0	118.8	81.2	1680	20.8	30.6	119	1600	21.0	28.8	125	34	4	1500	S	18.82	204-11			2d
			2e	3000	Line	63	1924		Sw.	BB	Gear	42	—			140	140														1500	F					2e
	Canada	Canadian National	3	2400	Line	56½	1918	6	P&F	B+B	Twin Gear	46	—	448	104	166	166	41.5	102.54	63.46	1280	23.4	20.2	130	1080	24.6	16.2	152	50	4	1200	F	25.80	600-5			3
	Chile	Bethlehem-Chile	4	1200-2400	Both	56½	1917	3	Ore	B+B	Twin Gear	52	—	594	132	239	239	59.75	120.6	118.4	1370	12.2	42.0	249	1190	12.7	35.2	201	35	4	1200	F	18.82	678			4
		Chilean-State	5a	3000	Line	66	1923	6	Exp P	1C+C1	Flex. Gear	42	30	701	173	259.8	210	35.0	155.6	104.2	2460*	36.0	25.8	108	2040	39.7	19.8	127	63	6	1500	F	21.56	2801-6			5a
			5b	3000	Line	66	1923	11	Loc P	B+B	Flex Gear	42	—	465	100	160	160	40.0	94.6	65.4	1640*	36.0	17.2	100	1360	39.7	13.2	118	56	4	1500	F	21.56	2501-11			5b
			5c	3000	Line	66	1923	15	Fr't	C+C	Flex. Gear	42	—	597	165	230	230	38.3	140	90	1800*	21.5	31.2	128	1500	23.9	24.4	153	44	6	1500	F	15.63	2001-15			5c
			5d	3000	Line	66	1923	7	Sw	BB	Hel. Gear	42	—	480	102	137	137	34.25	82.5	54.5	640	10.5	23.0	214	384	12.7	11.9	357	35	4	1500	S	16.63	2301-7			5d
	Mexico	Mexican	6	3000	Line	56½	1923	10	P&F	B+B+B	Flex Twin Gear	46	—	635	110	309	309	51.2	174	135	2756*	19.0	54.0	118	2520	19.5	48.5	123	40	6	1500		18.90	1001-			6
	U.S. of America	Baltimore & Ohio	7d	600	Rail	56½	1923	2	P&F	B+B	Twin Gear	50	—	474	114	240	240	60	175	65	1100	16.4	25.0	218	670	19.6	12.8	352	45	4	600	F	24.78	15-16			7d
			7a	600	Rail	56½	1903-06	4	Fr't	D	Gear	42	—	355	174¾	160	160	40.0	116	44	800	8.0	36.0	200						4	600	S	19.81	6-9			7a
			7b	600	Rail	56½	1910	2	P&F	B+B	Twin Gear	50	—	474	114	185	185	46.25	119	66	1100	16.4	25.0	168	670	19.6	12.8	216	45	4	600	F	24.78	11-12			7b
			7c	600	Rail	56½	1912	2	P&F	B+B	Twin Gear	50	—	474	114	200	200	50.0	135	65	1100	16.4	25.0	182	670	19.6	12.8	298	45	4	600	F	24.78	13-14			7c
		Butte-Anaconda & Pacific	8a	2400	Line	56½	1913-17	26	Fr't	B+B	Twin Gear	46	—	448	104	160	160	40.0	100	60	1280	15.4	30.6	125	1090	16.2	25.0	147	35	4	1200	F	18.83	39-64			8a
			8b	2400	Line	56½	1913	2	Pass	B+B	Twin Gear	46	—	448	104	160	160	40.0	100	60	1280	23.4	20.2	125	1090	24.6	16.2	147	50	4	1200	F	25.80	65-66			8b
										+ = Motive Power Unit																										
		Chicago Milwaukee & St. Paul	9a	3000	Line	56½	1917-18	4	Sw	BB	Gear	40	—	497	96	143.2	143.2	35.8	80.9	62.3	660	11.5	21.4	216	480	12.8	14.0	298	35	4	1500	F	17.64	10050-53			9a
			9b	3000	Line	56½	1916	84	Fr't	2B+B	Twin Gear	52	36	672	126	288	225	56.25	164	124	1720	15.25	84.5	167	1500	15.9	70.7	192	35	4	1500	F	18.82	10200-41			9b
			9c	3000	Line	56½	1920	5	Pass	1B+D+D+B1	Gearless	44	36	912	165	521.2	457.8	381.5	286.5	234.7	3500	27.1	48.5	149	3200	28.4	42.0	163	90	12	1500	F	—	10250-58			9c
			9d	3000	Line	56½	1920	1	Fr't	2C1+1C2	Geared Quill	68	36	1063	201	600.0	378	63.0	367.2	232.8	4680*	22.6	78.0	128	3400	26.4	48.1	176	55	6 Twin	750 1500	F	21.92	10300			9d
			9e	3000	Line	56½	1920	9	Pass	2C1+1C2	Geared Quill	68	36	1063	201	600.0	378	63.0	367.2	232.8	4680*	26.7	66.0	128	3400	31.2	40.8	176	65	6 Twin	750 1500	F	24.89	10301-09			9e
		Long Island	10	650	Rail	56½	1917	1	Fr't	BB	Geared	56	—	474	86	175.8	175.8	43.95	114.6	61.16	1200	21.2	23.2	146	1000	26.7	15.4	176	56	4	650		22.70	323			10
		Michigan-Central	11a	600	Rail	56½	1909	6	P&F	B+B	Twin Gear	48	—	474	114	200	200	40	135	65	1100	11.8	35.0	182	670	14.0	18.0	298	40	4	600	F	19.82	7500-5			11a
			11b	600	Rail	56½	1914	4	P&F	B+B	Twin Gear	48	—	474	114	240	240	60	175	65	1100	12.3	34.0	218	670	14.0	18.0	358	40	4	600	F	19.82	7506-9			11b
		New York Central	12a	600	Rail	56½	1906	35	Pass	2D2	Gearless	44	33	465	156	227.7	140.9	35.23	167.7	60.0	2200	38.5	21.0	103	800	60.0	5.0	284	80	4	600	S	—	1100-34			12a
			12b	600	Rail	56½	1906-09	12	Pass	2D2	Gearless	44	36½	516½	156	244.5	148.5	37.13	184.5	60.0	2200	38.5	21.0	111	800	60.0	5.0	306	80	4	600	S	—	1135-46			12b
			12c	600	Rail	56½	1913	10	Pass	BB+BB	Gearless	36	—	662	60	237	237	29.63	163	74.0	2320*	30.5	17.2	102	1760	37.5	11.4	135	85	8	600	F	—	1147-56			12c
			12d	600	Rail	56½	1914-18	16	Pass	BB+BB	Gearless	36	—	682	60	265	265	33.13	177	88.0	2600*	49.0	20.0	102	2000	58.3	14.0	133	85	8	600	F	—	1137-72			12d
		Pennsylvania	13a	600	Rail	56½	1910	2	Pass	2B+B2	Jackshaft-Siderods	68	36	779	86	332	208	52.0	205	127	2130	45.1	17.7	156	1570	54.8	10.8	211	80	2	600	F	—	32-33			13a
			13b	600	Rail	56½	1910	31	Pass	2B+B2	Jackshaft-Siderods	72	36	779	86	313	199	49.75	194	119	2130	47.8	16.7	147	1570	38.0	10.2	198	80	2	600	F	—	10-31 834-42			13b
			13c	600	Rail	56½	1910	1	Sw	B+B	Quill Gearless	56	—	465	102	195.1	195.1	48.79	100	95.14	630*	11.9	19.82	310	423	14.5	10.9	461	40	4	600	F	—	3951			13c
TOTAL AMERICA								340								86701					644150	1														

Table IV A. (Continued)

| | | |

Table IV B. Alternating Current Locomotives

Continent	Country	Railway	Key No.	Contact Line Volts	Contact Line Freq.	Gauge Inches	Year in Service	Number	Type of Service	Axle Classification	Method of Drive	Dimensions Inches: Wheel Diam. Driver	Wheel Diam. Idler	Length Overall	Rigid Wheel Base	Weights Thousands of Pounds: Total	On Drivers	Per Driving Axle	Mech Parts	Elect Parts	One Hour Rating: HP	MPH	TE Lbs /1000	Wt HP Lbs	Continuous Rating: HP	MPH	TE Lbs /1000	Wt HP Lbs	Max Safe Speed MPH	Motors: No.	Volts	Type	Gear Ratio	No. of Transformers	Road No	Wheel Arrangement	Cab	Key No.
America	Canada	Grand Trunk	25	3300	25	56½	1908	6[1]	P&F	C	Gear	62		353	192	132	132	44	73.6	58.4	750	10.8	26.0	176	668	13.5	18.5	197	30	3		Series	16.85	1	2635 2660			25
	U.S. of America	Boston & Maine	26[a]	11000	25	56½	1911	5	P&F	1B-B1	Geared Quill	63	42	581	84	260	204	51	141.8	118.2	1500[2]	24.4	23.0	173	1400	25.6	20.5	186	30	4	300	Series	22.91	1	4000 4004			26[a]
			26[b]	11000	25	56½	1917	2	P&F	1B-B1	Geared Quill	63	42	576	84	265[3]	217	54.2	147.3	118	1510[2]	24.2	23.3	176	1415	25.3	21.0	188	35	4	300	Series	22.91	1	4005 4006			26[b]
		Detroit & Ironton	27	1000 22000	25	56½	1924	2	Frt	AC+CA	Twin Gear Frictionless	42	—	702	132	340	340	42.5			2000	16.0	47.0	170	1750	17.0	40.0	194	35	8	600	Series DC	18.82	1				27
		New York New Haven & Hartford	28[a]	11000 600	25	56½	1907	41	Pass	1B-B1	Gearless Quill	62	33	450	96	220[1]	169	42.3	108.1	112	1420[2]	54.5	97	155	1125	66.0	64	195	88	4	220	Series	—	1	01 041			28[a]
			28[b]	11000	25	56½	1916	1	Sw.	2B+B2	Gear Sideroad	54	33	744	120	291	194	48.5	172	119	1800[2]	23.0	27.0	166	1600	26.4	22.2	187	45	4		Series	35.71	1	068			28[b]
			28[c]	11000 600	25	56½	1910	1	P&F	1D1	Gear Quill	63	36	560	132	234[6]	174	43.5	114.1	120.3	1700[2]	36.0	18.3	138	1350	41.9	12.6	174	54	4 Twin	275	Series	22.92	1	069			28[c]
			28[d]	11000	25	56½	1910	1	Sw	1B-B1	Side-rod	57	36	644	96	270	192	48	138	132	1260[2]	32.0	16.0	214	1044	35.6	12.0	258	61	2	310	Series	—	1	070			28[d]
			28[m]	11000 600	25	56½	1910	1	Pass	1B-B1	Gear Quill	63	42	476	84	269[3]	186	46.6	160.3	129	1600[2]	37.0	13.2	180	1160	48.0	11.8	249	55	4	300	Series	34.79	1	071			28[m]
			28[f]	11000 600	25	56½	1911	1	Pass	1B-B1	Gear Quill	63	36	476	84	256[4]	193[3]	47.6	128.6	128	1600[2]	37.0	13.2	160	1160	48.0	11.8	222	55	4	300	Series	34.79	1	072			28[f]
			28[g]	11000 600	25	56½	1912 3	3	Pass	1B-B1	Gear Quill	63	36	600	96	248[1]	189[3]	47.4	133	115.1	1700[2]	36.0	18.2	146	1350	41.5	12.4	184	54	4 Twin	275	Series	22.92	1	073 075			28[g]
			28[h]	11000	25	56½	1912 3	36	Frt	1B-B1	Gear Quill	63	36	600	96	219[3]	165	41.2	120.3	98.8	1700[2]	25.1	24.8	129	1350	29.8	17.1	163	41.5	4 Twin	275	Series	17.97	1	076 077.1			28[h]
			28[i]	11000	25	56½	1911	1	Sw.	B+B	Gear Quill	63	—	444	84	158	158	39.5	79.7	78.3	750[2]	12.2	23.2	210	572	14.5	14.8	276	25	4	190	Series	17.101	1	0200			28[i]
			28[j]	11000	25	56½	1912	15	Sw	B-B	Gear Quill	63	—	450	84	159[3]	159[3]	39.8	83.4	75.8	750[2]	12.2	23.2	212	572	14.5	14.8	278	25	4	190	Series	17.101	1	0201 0215			28[j]
			28[k]	11000	25	56½	1919	5	Pass	1C1+1C1	Gear Quill	63	36	828	151	350	233	38.8	173.5	176.5	2550[6]	46.6	21.0	137	2025	52.5	14.5	174	70	6 Twin	275	Series	27.81	1	0300 0304			28[k]
			28[l]	11000 600	25	56½	1923	12	Pass	1C1+1C1	Gear Quill	63	36	802	151	358	240	40.0	189.5	158.5	2510[2]	48.5	19.3	143	2050	58.8	13.1	175	77	6 Twin	275	Series	25.89	1	0305 0316			28[l]
		Norfolk & Western	29[a]	11000	25	56½	1915	24+	Frt	1B+B1	Gear-Jackshaft Sideroads	62	30	638	132	300	249	62.3	190	110	1600	14.3 28.6	42.0 21.5	187	1260 1450	14.3 28.6	33.0 19.0	207	35	2 Twin	725	3 Φ Induc	18.85	1	2500 II EI-22			29[a]
			29[b]	11000	25	56½	1924	8+	Frt	1D1	Flex Gear-Jackshaft-Sideroad	63	33	583	198	414	300	75.0	251.5	162.5	2030 2315	14.1 28.3	34.0 31.5	174	1700 2000	14.2 28.4	34.0 26.3	207	38	2	850	3 Φ Induc	21.100	1	7512.9 12338			29[b]
		Pennsylvania	30[a]	11000	25	56½	1917	1	Frt	1C+C1	Gear Jackshaft Sideroads	72	36	918	160	516	439.2	73.3	258.4	257.6	4800	20.4	88.0	108	4000	20.5	73.0	129	35	4	850	3 Φ Induc	21.106	1	1931 (2)			30[a]
			30[b]	11000	25	56½	1924	3	Frt	1D1	Flex Gear-Jackshaft-Sideroads	80	33	819	267	408	300	75.0	225.1	182.9	3300	21.0	59.0	124	3070	23.0	50.0	133	35	4	350	Series	30.118	1	LS			30[b]
		Virginian	31	11000	25	56½	1924.5	36+	Frt	1D1	Flex Gear Jackshaft Sideroads	62	33	609	198	450	312	78.0	267	163	2030 2315	13.4 27.0	56.6 33.0	181	1700 2000	13.5 27.1	47.4 27.6	215	35	2	850	3 Φ Induc	20.100	1				31
											·-+= Motive Power Unit																									
Total	America	—= Under Constn.						205								58693					363950																	
	Austria	Mariazell	32	6600	25	30	1910 14	16	Frt	C+C	Gear-Jackshaft Sideroad	31.3		434	94	104	104	17.3	53	51	592	21.7	10.2	175					31.0	2	220		3.0	2	1-14			32
		Mittenwald	33	15000	16⅔		1912-14	12	Frt	1C	Jackshaft Sideroad	40.7	34.2	405	157	117	92.3	30.9	64	53	789	18.7	15.9	148	492			238	28.0	1	810	Repul	—	1				33
		Vienna-Pressburg	34	16500			1914	8	P&F	1B1	Jackshaft Sideroad	40.7	34.2	415	157	118	61.8	30.9	60	58	740	24.2	11.5	159	740	36.4	7.7	159	46.6	1	490	Ser Rep	—	1	EP1-B			34
		Austrian State	35[a]	15000	16⅔		1922	7	Frt	1C+C1	Gear Jackshaft Sideroad	53.1	34.2	775	152	250	192	32	151	99	2465	33.6	27.6	101					40.4	4	575	Series	3.22	1				35[a]
			35[b]	5000	16⅔		1923	21	P&F	1G1	Gear Jackshaft Sideroad	66.9	39.1	504	223	157	96	32	73	84	1340	29.2 31.7	172 15.9	115					43.5 49.8	2	400	Series	4.21	1				35[b]
			35[c]	15000	16⅔		1923	20	Frt	E	Gear	53.1		512	154	160	160	32	81.6	78.4	1450	24.9	21.8	110					31[1]		385	Series	6.0	1				35[c]
		Baden State (Wiesenthal)	36[a]	15000	15	56½	1912	12	P&F	1C1	Jackshaft Sideroad	41.3	33.4	486	157	151.5	92.5	30.3	80.8	70.7	1035	28.0	10.2	146	769	49.1	6.6	197			300	Series	—	1	A2-1			36[a]
			36[b]	15000	15	56¼	1913	2	Frt	1C1	Jackshaft Sideroad	58.2	39.0	470	142	154	95.9	31.9	86	68	798	34.2	9.5	192	640			241			1200	Repul	—	1	A3-1			36[b]
		Bavarian State	37[a]	15000	16⅔	56½	1914	5	P&F	1C2	Jackshaft Sideroad	43.3	33.4	485			94.5	31.5	3	72.0	891	24.0	13.7	204		33.0	7.3		49.7	1		Series	—	1	EP3/6 20101-5			37[a]
			37[b]	15000	16⅔	56½	1916	5	Frt	BB	Gear	43.3	—	433	98.5	123	123	30.8	70.9	53	785	18.6	15.0	156		18.6	7.5		31.1	4		Series		1	EG-4 20201-5			37[b]
			37[c]	15000	16⅔	56½	1916	5	P&F	1C2	Jackshaft Sideroad	45.3	33.4	528	102	207	106	35.3	119.0	88	1280	31.1	15.4	162		49.7	7.3		49.7	1		Series	—	1	EP3/6 20121-5			37[c]
			37[d]	15000	16⅔	56½	1913	5	Frt	1C1	Jackshaft Sideroad	41.3	33.4	478	157	152	92.6	30.9			986	18.6	19.8	154					31.1			Series	—	1	EP24 002			37[d]
			37[e]	15000	16⅔	56¼	1920	2	Frt	B+B	Gear Jackshaft Saitch Yoke	49.2	—	490	108	134	134	33.7	76.8	57.6	886	18.6	17.0	150		18.6	13.2		31.1	2	415	Series	3.50	1	EG 20221			37[e]
		Unassigned	37[f]	15000	16⅔	56½	1924	10	Exp P	1D1	Buchli Gear	63	39.4	612		225	160	40.0			2360	39.0	22.7	95	1970	39.0	18.9	114	68	4		Series		1				37[f]
			37[g]	15000	16⅔	56¼	1924	5	Exp P	2C2	Jackshaft Sideroad	63	39.4	619		253	120	40.0			1450			174	1180			214	68	1[4]		Series	—	1				37[g]
			37[h]	15000	16⅔	56½	1924	35	Pass	2B2	gear jackshaft jackshaft Sideroad	55.1	39.4	640		277	160	40°			2270			122	1980			140	56	4		Series		1				37[h]
			37[i]	15000	16⅔	56½	1924	19	Pass	1C1	gear jackshaft jackshaft Sideroad	55.1	39.4	453		170	120	40°			1180			144	986			172	44	2		Series		1				37[i]
			37[j]	15000	16⅔	56½	1924	37	Frt	1B-B1	Gear-jack-shaft-sideroad	55.1	39.4	630		236	160	40°			1890			125	1580			148	40	2		Series		1				37[j]
			38[a]	15000	16⅔	56½	1911	1	Pass	2B1	Jackshaft Sideroad	63	39.4	493	118	162	124	36.2	102.5	59.6	1015	46.5	8.0	160	828	74.6	4.1	196	80.8	1	460	Series	—	1	ES-1			38[a]
			38[b]	15000	16⅔	56¼	1911	1	Pass	2B1	Jackshaft Sideroad	63	39.4	493	118	158	70.6	35.3	99	59	1180	49.1	9.0	134	591		4.7	267	80.8	1	570	Doubly fed series	—	1	ES-2			38[b]
			38[c]	15000	16⅔	56½	1912	1	Pass	2B1	Jackshaft Sideroad	63	39.4	493	118	159	70.6	35.3	100	59	1480	49.1	9.8	107	1085	52.9	7.7	147	80.8	1		Series	—	1	ES-3			38[c]

Table IV B. (Continued)

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Table IV B. (Continued)

CONTINENT	COUNTRY	RAILWAY	KEY NO.	CONTACT LINE VOLTS	CONTACT LINE FREQ.	GAUGE INCHES	YEAR IN SERVICE	NUMBER	TYPE OF SERVICE	AXLE CLASSIFICATION	METHOD OF DRIVE	DIMENSIONS INCHES WHEEL DIAM. DRIVER	DIMENSIONS INCHES WHEEL DIAM. TRAILER	DIMENSIONS INCHES LENGTH OVERALL	DIMENSIONS INCHES RIGID WHEEL BASE	WEIGHTS THOUSANDS OF POUNDS TOTAL	WEIGHTS THOUSANDS OF POUNDS DRIVERS NO	WEIGHTS THOUSANDS OF POUNDS PER DRIVING AXLE	WEIGHTS THOUSANDS OF POUNDS MECH. PARTS	WEIGHTS THOUSANDS OF POUNDS ELEC. PARTS	ONE HOUR RATING HP	ONE HOUR RATING TE LBS/1000 LBS	ONE HOUR RATING Wt HP. LBS	CONTINUOUS RATING HP.	CONTINUOUS RATING TE LBS/1000 LBS	CONTINUOUS RATING Wt HP LBS	NO. OF SPEEDS	SYNCHRONOUS SPEED MPH	MAX SAFE SPEED MPH	MOTORS NO	MOTORS VOLTS	MOTORS VENTILATION	MOTORS GEAR RATIO	NO OF TRANSFORMERS	ROAD NOS	WHEEL ARRANGEMENT	CAB	KEY NO
AMERICA	U.S. OF AMERICA	GREAT NORTHERN						4																														
TOTAL AMERICA																																						
EUROPE	ITALY	ITALIAN STATE	47a	3000	15	56½	1902	2	Fr't	B+B	Gearless	55	—	405		1014	920	254	463	56.2	6000	888	18.6			4	3000			19.81	2	6-34			47a
			47b	3000	15	56½	1903	3	Fr't	1C1	Scotch Yoke	69	38		445	1368	926	309	663	70.6		1184	11.5		2	3000						6-36			47b
			47c	3000	15	56½	1906	4	Fr't	1C1	Scotch Yoke	59	33		445	1368	920	309	706	64.5		1480	14.3		3	3000						6-38			47c
			47d	3000	15	56½	1909	180	Fr't	E	Scotch Yoke	42	—	374	151	1328		266	666	66.1		1913	23.9	67			4	3000					E 650			47d
			47e	3000	15	56½	1915	16	Pass.	1C1	Scotch Yoke	64	35.4	423		161	105.9	35.3	72.7	88.3		2642	21.4	61			4	3000					E 330			47e
			47f	3000	15	56½	1917	6		2C2	Jacksonville Sidercad	64	37.8	525	138	2028	1191	39.1	1018	95.		2604	21.0	78			4	4656	62.1	2	3000	—	—	E 332			47f
			47g	3000	15	56½	1918	15		2C2	Jacksonville Sidercad	64	37.8	585	138	2028	1103	36.8	1107	92.7		2604	21.0	76			2	4656	62.1	2	3000	—	—	E 331			47g
			47h	10000	45	56½	1923	6		1D1	Geared Jackshaft Scotch Yoke	64		571		2004	1412	35.3				2662	21.4	75			4	4656		2			2.7			47h
			47i	10000	45	56½	1923	10		E	Geared Jackshaft Scotch Yoke	42	—	374	251	1671	1671	33.5				2268	21.4	74			2	3110		2			3.625			47i
			47j	10000	45	56½	1924	10		1D1	Geared Jackshaft Scotch Yoke					196			191	117.9		5280	31.9	57			2	2870 4150	62	2						47j
			47k	3600	16⅔	56½	1924	150	Fr't	E	Scotch Yoke		—			1585	1585	31.7				2680	33.0	59			2	3110	62	2	3600	—	—	351			47k
			47l	3600	16⅔	56½	1922	15	Fr't	E.	Scotch Yoke		—			1585	1501	31.7				2680	33.0	59			4	165 2330	62	2	3600	—	—	552			47l
		—=Under Constn.	47m	3600	16⅔	56½	1924	30	Pass	1D1	Scotch Yoke					2025	1324	35				2680	20.9	76			4	71 33 445 42		2	3600	—	—	431			47m
			47n	3600	16⅔	56½	1923	40	Pass	1D1	Scotch Yoke					165	105	35.		93.5		2680	26.4	62			4	15-23 31-46		2	3600	—	—	333			47n
		SIMPLON TUNNEL	47o	3000	15	56½	1907	3	P & F	1C1	Scotch Yoke	64	33.5	485	193	135	100	33.3	74	64	1085	9.6	127	8.9		2	412.3		2	3000	—	—	364			47o
	SWITZERLAND		47p	3000	15	56½	1909	2	P & F	D	Scotch Yoke	49	—	499	67	152	152	38	74	78	1677	14.6	91			4	428		2	3000	—	—	367			47p
			47q	3000	15	56½	1915	1	P & F	1D1	Oerlikon Scotch Yoke Jackshaft	49	33.5	492	83	195	163	38.3	98	97	2760	23.6	111			2	44.1 46.2		2	3000	—	—	371			47q
TOTAL EUROPE								438								17493					1207099														
GRAND TOTAL THREE PHASE								592								18410					1213100														

simple classification, analysis and decision, whereas with electric locomotives there may be but slight resemblance which manifestly imposes difficulties in classification and broad discussion. It should be apparent also that any broad generalization as to electric locomotive development must necessarily be more or less arbitrary; but the writer believes, however, that an historical tabulation of types with certain data and explanation best fulfills the purpose of this paper.

Methods of Electrification

The use of electricity as a source of power pre-supposes a conducting system and a contact system parallel to the rails. There is now general agreement, in America at least, that this latter should be overhead and at high voltage. This may be alternating current or direct current. Each has its own advantages and each together with the particular service contemplated governs the general type and details of the motive power or locomotive used.

Table II shows the various methods of electrification classified as to kind of current supplied by the contact system, each system with its various and alternate possible arrangements. This shows the provisions necessary for electric supply to the locomotives, and, for the locomotives, in turn, different and alternate selections of equipment. It is seen that the greatest range of selection obtains with the single phase system. Conclusion as to the most desirable system will, however, be determined not by conditions pertaining to locomotives alone, nor to power supply alone, but by the relative importance of each and, especially, will always be governed by the overall objective—the most effective use of the railroad.

Except for purely local conditions which prevail for some services, such as subway and elevated and for such conditions as may be permissible in England, the use of low voltage direct current is not now given practical consideration for extended electrification. The three phase system is contemplated by the requirement for two separately insulated contact wires over each track. It is also limited in voltage. For these reasons, notwithstanding its highly successful operation and its advantages in locomotive weight-efficiency, no adoption or extension of this system is taking place except in Italy where a large and comprehensive expansion is under way. There remain then the other two systems for heavy traction, high voltage direct current at 1,500 to 3,000 volts, and single-phase alternating current at 11,000 to 22,000 volts or higher.

The advantage of high voltage, wherever used, is to increase the range of distance for the economical use of electric power. Relatively speaking, the higher the voltage on the contact wire the less number of generating stations if power is fed direct, or sub-stations with the usual indirect feed. The effective use of transforming or converting apparatus at substations as determined by the size and frequency of train operations, establishes the relative cost and economy of the voltage selected, and thereby the system.

It should be noted that of the countries which are definitely embarked on electrification programs, France, Holland and Japan have decided in favor of standardizing on 1,500 volts direct current, Chile at 3,000 volts and South Africa at both 1,500 and 3,000 volts, while Switzerland, Sweden, Norway, Germany and Austria have standardized on single-phase at 16,000 volts.

England is extending its present single-phase installa-

tion, its low voltage direct current installations and also intends to use 1,500 volts direct current.

In the United States one of the existing installations of low voltage direct current is being extended, one at 1,500 volts direct current is authorized, three existing single-phase installations are being extended, and an additional one is under construction.

Reference to column locomotive, Table II, will show the major elements required on the locomotives for the various systems. As these differ, the design of locomotive differs as to number and size of motors, their mounting and connection to each other and to the driving mechanism for propulsion. The type, amount, size and weight of the electrically connected equipment may vary widely. This, in turn, influences both the locomotive structure and wheel arrangements.

General

An electric locomotive, like a steam locomotive, has two main functions—that of an engine for developing drawbar pull and that of a vehicle. Its purpose is to develop tractive effort from standstill to and at certain speeds. In order to do so, it must be able to run safely over the track, tangent or curved, at those speeds, without undue stresses in its own structure or that of the permanent way, and without undue wear of rail or tires. The primary objective of the design is, of course, to secure both a good engine for developing drawbar pull and a good vehicle. This is relatively simple when operation is limited to low speeds and with little critical curvature. When, however, high speeds or high speeds with critical curvature, in addition to the two-way operation, must be provided for, it becomes less simple, even with the great latitude in design and the possible combinations which the electric locomotive permits. The result is usually a compromise between what might be called the best engine of traction and the best vehicle.

A large motor may drive more than one axle, in which case there is required a side rod drive direct or through gearing, or a number of small motors may each drive a single axle through a direct connection or through gearing. Guiding or idle axles may or may not be used depending upon the speed, curvature and track stress or axle loading permissible.

The motive power units under common control which is, by the way, a proper definition of an electric locomotive, may have a single wheel base, or an assembly or short or long wheel bases, coupled together by cab or by hinges or by drawbars. Each individual unit may have or may not have auxiliary trucks for guiding or for bearing weight. Each unit may be an independent vehicle or it may be a vehicle whose guiding or stability is effected by the preceding or following unit through hinges. The cab structure may be integral with the locomotive frame or it may be independently borne, and attached to two or more wheel bases.

It should be borne in mind that the mechanical parts form the link between the electrical apparatus and the track and the adequacy of their detail design and the proper characteristics of the whole are essential to the success of an electric locomotive.

How these various possible forms have been made use of to meet the various requirements and the various practices which have been evolved, is shown by Table IV, A & B which gives the date of construction, detail of type, capacity and the more important data of substantially all locomotives built or building up to date.

Conclusions drawn from these data must be made with a full consideration of all the critical factors involved. The table may contain certain errors and omissions but is deemed, nevertheless, sufficiently accurate to indicate broadly the development of the electric locomotive. It should be noted that the tabulation includes certain experimental locomotives built solely for development purposes in Germany and Switzerland prior to their adoption of extensive electrification programs.

The table might be taken without explanation as complete as to types of motors and the different drives, excepting for the causes which influence and the reasons which govern their selection. Therefore, specific references to the various uses and practices follow.

Within certain limits the electric system adopted and the service for which the locomotive is intended are the chief factors which will govern the fundamental design of electric locomotives. The electric system chosen together with the service requirements will determine the type of motor, its characteristics and its size and speeds. The type of motor and restriction to driver weights will determine the drive within limits of narrow choice; and the drive will, in turn, together with the absence or presence of critical curvature essentially determine the configuration of the rigid running gear. The necessity for auxiliary trucks will be determined mainly by the service requirements, chiefly that of speed, and presence or absence of critical curvature; but, in certain cases, will be determined or influenced by the limit of axle loading or by placement of driving motors or placement and amount of auxiliary apparatus.

Types and Characteristics of Motors

The high voltage d.c. system requires the use of one type of motor, the d.c. series motor. The single phase system permits the use of the a.c. series motor, the a.c. induction motor and the d.c. series motor.

The direct current motor is the outgrowth of the street railway motor. The speed curve falls rapidly as the tractive effort increases, so that a maximum tractive effort is available at low speeds, whereas at high speeds the tractive effort falls. With the usual series motor the only practical way of controlling speed (except for the restricted range of field control) is by varying the voltage across the motor armatures. This is accomplished by use of external resistance and by changing motor combinations.

The limitations of design are influenced not only by speed and load requirements but by the need for stability against flash-over. This last is also affected by the conditions of current supply and is a material factor in determining the size and weight of motor selected.

The alternating current series motor characteristic is somewhat steeper than that of the direct current series motor. Inasmuch as the use of alternating current in a motor is always accompanied by induced currents due to transformer action, this, in a series commutator motor, affects the conditions under the brushes which determine their action, thus restricting within definite limits the torque output per motor pole (particularly at or near standstill), and this, where needed for slow or frequent heavy starting, will result in a heavier motor weight and cost than for direct current motors at the lower voltages

for the same service, especially with the smaller capacities of individual motors. The voltage of the a.c. motors is low, their stability high, and they may be run on ungrounded circuits so that under proper conditions their operation is comparable to direct current motors. The condition of current supply is a factor of less importance owing to the transformer which is interposed between contact wire and motors. Control of speed is easily accomplished and is relatively simple and efficiently secured by the use of taps from the transformer without changing motor grouping or the use of external resistance.

The three phase induction motor, used also with phase converter, is practically a constant speed motor and has characteristics very different from the two described above. Additional speeds are obtainable through varying (by connection) the number of poles or by cascade connections between motors, but in general for freight service for which this type has many advantages, it is seldom necessary to have more than two speeds. Acceleration is accomplished by varying the external resistance inserted in the motor secondaries. Very high starting torques are obtainable with this type of motor, as well as capacity to carry heavy loads. As constant speed is maintained irrespective of the load, the horsepower input will vary almost directly with the tractive effort. As no commutators are used this is the simplest form of electric motor and the questions of commutation and stability do not have to be considered.

All three types lend themselves to regeneration. The induction motor is inherently the best by far as it automatically, without additional apparatus for switching, separate excitation or regulation of any kind, becomes a generator, whenever the locomotive while descending a grade exceeds the synchronous speed. No question of stability, flashing or expert manipulation enters into the matter at all.

Both the direct current series motor and the alternating current series motor have been successfully used for regeneration although considerable additional apparatus or the use of certain of the main motors in order to obtain separate excitation when regenerating, is necessary.

The d. c. series motor, if furnished a local supply of direct current from a motor generator set on a single phase locomotive secures the utmost in favorable conditions for the operation of a direct current series motor. The motor may be designed to secure the maximum obtainable economy of weight and space and also the most appropriate voltage across commutator and winding can be used. Furthermore, the motors may be operated on an ungrounded circuit. This simplifies the insulation and creepage problem and insures better commutation and stability although the need for this is materially less, due to both the motor generator and the transformer being interposed between the motors and the contact system. Due to the wide range of speed control, higher horsepower can be maintained at higher speeds, and due to the control of generator voltage a most simple control system for both motoring and regeneration is secured. By the use of a synchronous motor on the motor generator set most favorable conditions of power factor can be realized. Rheostatic losses on this type of locomotive are practically eliminated. Furthermore, the resulting economy in size and weight of both motors and control considerably offsets the additional weight of motor generator set required.

Figure I shows the typical characteristics of the direct current series, the alternating current series and the alternating current induction motors, and the direct-current series motor used with locomotive motor generator set, as well as that for the steam locomotive.

In general, then, it can be said that the direct current series motor for a given weight has certain outstanding advantages for certain applications owing to its torque speed characteristics. As to speed control and as a generator it has certain disadvantages, all of which by additional apparatus and design can and have been successfully met. If used with a motor generator set on the locomotive its limitations are very greatly reduced. It lends itself particularly to subdivided power on account of its size-and-weight-efficiency and ease of grouping which is required to overcome its speed control limitations. The individual drive therefore will be found best adapted for this type of motor. This can be the gearless direct drive, geared, axle hung (the street railway type), frame mounted with quill, (geared or gearless) or with universal rod and pin drive.

With the greater space requirements needed by a single phase series motor its use as direct gearless and for axle hung mounting is restricted to the relatively smaller sizes, while for frame mounting with geared quill or universal drive space limitations do not usually govern. The necessity for laminated structure, distributed windings and more brushes, together with the relatively lighter frame sections, adapts this type of motor in the largest sizes to frame mounting with collective drive (with or without gears) by which one motor drives more than one driving axle.

The induction motor is adapted particularly for heavy service where constant speed is desirable, for reasons of simplicity of control, and for the attainment of the highest weight efficiency with large motors. These make the collective drive the desirable one for this type of motor.

Types and Classification of Drive

Drives can be definitely classified as individual and collective. The individual drive lends itself particularly to both the direct and the alternating current series motors, excepting the latter when very heavy tractive efforts are involved, or when high motor weight efficiency or light axle loadings are the requisites. Collective drives lend themselves particularly well to such conditions and also to the best conditions for the use of the induction motor.

The continental engineers have apparently favored the collective drive for the alternating current series motor even in cases where the individual drive might have been used.

For the further description, advantages and limitations presented by the various drives, reference is made to Table III.

(a) The single reduction geared, nose and axle suspended motor with single or twin gears has been the logical development from the early street car motor. Its advantages are due to its extensive use, its simplicity and relative cost. It is most effective for slow speed freight locomotives and when the individual motor rating or relative tractive effort is not too great. Its disadvantages are the restriction to armature length and diameter, the relatively high-non-spring-borne-weight on the axle (the effect of which is neutralized somewhat by the spring nose suspension and the use of spring gears), and to its relative exposure and inaccessibility. Its limitations are

greater where twin gears are used due to the greater restriction in length between wheel hubs.

(b) The advantage of the direct drive with armature mounted upon the axle is the directness by which transfer of torque to the wheels is accomplished with the entire elimination of drive mechanism and all losses connected therewith. The elimination of driving losses is to a material extent offset by the high copper losses of the field due to the large number of turns required by the large air gap and to the high copper losses of armature due to the considerable percentage of relatively inactive windings. The slow motor speed results in a low weight efficiency of motor and the proximity of motor to the roadbed imposes certain difficulties from exposure. The use of this type is necessarily confined to relatively high speed passenger service owing to the limited torque capacity.

(c) The direct quill drive has the advantage that it permits the use of a motor whose armature as well as its field frame is completely spring supported. It further permits relative economy in design and use of windings and secures a normal design of low speed motor. It has, however, the common disadvantage of low speed and relatively low weight efficiency of the motor and is further subject to certain inaccessability of the spring drive elements and to proximity to the roadbed. This type is likewise limited to high speed service on account of its limited torque capacity.

(d) The quill geared drive secures completely spring borne frame mounting of the motors, the elevation of the motors from the roadbed, and their better placement as to overall weight distribution of the locomotive (notably that of height of center of gravity). The motors are less exposed and opportunity is afforded for twin motor mounting which secures certain advantages, notably those of simplified gearing, less space restrictions, reduction in voltage across commutators and better opportunity for motor groupings when required for speed control.

The disadvantages are mainly those due to the maintenance and replacement of the springs or of the elements of the drive which are subject to relative motion. These objections have more or less importance depending on the torque transmitted and on the relative vertical displacement of axles to locomotive frame which is governed both by number of axles and conditions of track surface. There may be some further objection due to the spring connections acting in parallel with the equalization system.

The quill geared drive is in successful use with both d.c. and a.c. series motors, both for high and low speed for all classes of passenger service, and for medium heavy freight and switching locomotives in this country and for all services with a.c. series motors.

(e) With frame mounting and individual universal rod and pin connection from gears to drivers the same advantages of placement obtain as with the geared quill drive with the substitution of mechanism for the springs which overcomes objection to spring drive maintenance and possible weight transfer at the expense of somewhat increased complication. This type of drive has distinct promise for services where individual drives are permissable.

(f) The direct side rod drive. This was the result of the natural attempt to get away from the limitations of the street railway type motor and to follow the design of the steam locomotive in order to retain certain of its favorable characteristics such as high center of gravity, favorable wheel spacing, etc. It has been used experimentally on several locomotives usually with direct connected oblique main rods. Under certain dynamic conditions, excessive stresses in rods or pins are developed. This design has not been duplicated to any great extent for succeeding locomotives, and, where used, two oblique rods and two motors are usually employed.

(g) The direct side drive with scotch yoke was first generally used by von Kando on the three phase locomotives designed by him for the Italian Railways. The scotch yoke has the advantage of permitting vertical movement between motors and drivers and also admits of motor mounting somewhat above the center line of drivers. This drive is well adapted for the direct connection to large slow speed motors and is in extensive use on a large number of Italian locomotives. The same principle of sliding rod bushing has been used in various adaptions of side rod drive for single phase locomotives.

(h) Jack shaft rod drive. This drive was the logical development of the direct side rod drive. By its use certain stresses due to the static and dynamic characteristics of the general type of drive were better taken care of. It is limited to the higher speed locomotives on account of the low weight efficiency of the motors at the lower speeds. It has found a limited number of applications both with d. c. and a. c. motors. A notable example of its successful use is the 33 d. c. locomotives of the Pennsylvania Railroad at their New York Terminal. It is at present, to a very limited extent, being duplicated for certain services by certain continental railways, a flexible element, however, being interposed at the armature.

(i) Geared jack shaft drive. This is a modification of the direct jack shaft drive through the employment of gears which admits the use of higher speeds and lighter motors and main rod with minimum angularity relative to the side rods. The use of flexible gears secures the advantageous cushioning of drive. The incorporation of these various features has practically eliminated the major troubles incident to the side rod drive under certain conditions. It is now in successful operation in all classes of service. Instead of the simple main rod, in certain applications the scotch yoke or its principle has been used.

The common disadvantage of all drive connections between the rotating masses of the motors and those of the wheels is due to changes in angular velocity between the two, each having its own inertia. Rod drives are in particular more susceptible to this, owing to the inclusion of more driven wheels, larger motors, and more elements with clearance, together with transfer of load from one side to the other due to the use of crank motion. The difference in these respects from those obtaining with steam locomotives lies in the broad fundamental kinematic difference between the two—the electric drive is a mechanically closed system while the steam drive, on the other hand, is an open system. Experience has shown this to be a vital difference and one which must be provided for in order to satisfactorily take care of all conditions and speeds. These provisions are effected either by designing the drive and mechanical parts involved strong enough to withstand the high stresses imposed under certain conditions (either with or without flexible elements);

or, on the other hand, a lighter design (preferably with flexible elements) with provision for close clearances and their rigid maintenance.

Locomotive Assembly

In wheel and axle arrangement, access to and mounting of motors, access to and mounting of control, and current collecting and auxiliary equipment, the locomotive assemblies may differ widely.

Motors and Drive:—The various forms of motor and drive have been discussed in more or less detail by reason of their being essentially major elements.

Running Gear:—It will be noted from Table IV that running gears bear different relationships to each other and to the cab or frame structures. The simplest form is the independent-cab and four wheel swivel truck with tractive effort transmitted through cab underframing and center pins, for locomotives of lesser tractive efforts.

For the larger locomotives the running gear may comprise a single wheel base alone or several connected by hinges, or by coupling either with or without buffers. For the slower speed locomotives auxiliary trucks are often not needed, but where operation is required over a considerable amount of critical curvature, guiding is improved by the use of hinge connection. For the heavier and higher speed locomotives auxiliary trucks are employed; these are of varied types, both two-wheel and four-wheel. They serve various functions such as carrying weight, easing track stresses, providing stability on tangents at high speeds, and guiding on curves. The last two may be supplemented by hinge or special connections which utilize the friction forces of the drivers or the lateral component due to tractive effort to secure guiding.

The general practice in America follows the steam practice of supplying restraint to trucks by the use of heart links or rockers, without provision for special driver axle play. The usual continental practice, on the other hand, is to employ spring or inclined plane, or combined motion with adjacent driver. Long rigid wheel bases are commonly employed even with high curvature by the provision of lateral play of driving axles and driving rods.

The two-way operation of electric locomotives having restraint elements in auxiliary trucks imposes greater difficulties in securing favorable guiding on heavy curvature than is the case with steam locomotives with one-way operation. This may be overcome or eliminated by adequate attention to design. Owing to the great variations in the design of auxiliary trucks and difficulty of classification these have not been indicated in Table IV.

Wheel Arrangement:—The wheel arrangements or configurations of running gear in Table IV can be readily recognized from the diagrams. The continental classification was used as it simplified compilation of data and as the diagrams fully describe. The adaptability of the various drives to various wheels spacings and arrangements will be readily apparent from the table.

Axle Loading:—Practice as to permissible axle loading in America differs widely and has not been definitely established. Steam locomotive axle loadings have progressively and universally increased, likewise those of the electric locomotives until on some of the notable recent locomotives the loading reaches approximately 80,000 pounds per driving axle. However, owing to the complete counterbalance for all speeds, obtainable on electric locomotives (due to the absence of reciprocating parts) this loading is considered to be less severe on structures and permanent way than a steam locomotive, even with its lesser static loading, because the latter has a periodic increment due to dynamic augment occasioned by imperfect balance of reciprocating parts. For conditions of high speed or heavy axle loading, due provision can be and usually is made to minimize the non-spring-borne weight, and also to secure the most favorable wheel spacing for minimizing track stresses.

Auxiliary Apparatus and Cab:—For control of the motors and various other purposes, switches and other apparatus and equipment are required. There are two general types of mounting; one, with a self-contained cab, mounted on two or more trucks or running gears, and carrying and housing the auxiliary apparatus; the other, with the cab structure borne by and integral with each running gear. The first type having relative movement requires a much heavier cab structure with special supports, and also flexible connections for the electrical circuits, air sand and oil lines, and forced ventilated system. In the case of the integral cab these flexible connections are not required. Owing to the absence of relative movement between motors and control apparatus it becomes possible to mount control and ventilating equipment directly upon the motors and all other equipment may be mounted directly upon the locomotive frame. The cab structure thus becomes merely a housing for the protection of the operators and apparatus. As will be noted from Table IV combinations of both are sometimes used.

Miscellaneous:—The various other elements of an electric locomotive which have a material influence upon the design of running gear and cab structure, such as equalization, spring systems, current collecting devices and braking arrangement and equipment, could not well be included within the scope of this paper.

Conclusion

While the steam locomotive is a self-contained entity in most of its details of design and of its operation, it is seen that the electric locomotive, on the other hand, is dependent on and controlled, both as to design and possible limits of operation, by the other necessary component elements of a Railroad Electrification. Conclusions on electric locomotives are consequently a compromise to realize the overall objective, therefore discrimination is necessary when comparisons of electrifications are based solely on locomotive design, costs or performance. Review of the tables herein will show the history and trend of locomotive development as to systems, types and countries. While both the applications and the services differ, so do the objectives—whether they be, for instance, fuel savings or future service conditions.

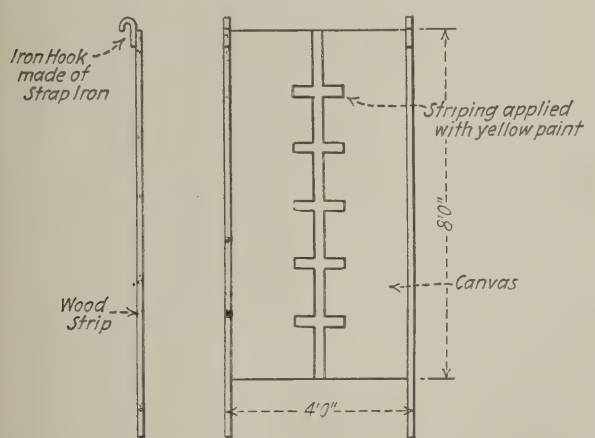
Transportation, so largely the yardstick of civilization, must and will be improved everywhere. Where the advance is the greater, there will be the greater achievements result. The design and perfection of the electric locomotive, it will be noted, are being given intensive consideration universally, although here in America railroad development of recent years has been relatively slow. The present notable activity of our heaviest carriers—The Pennsylvania, the Norfolk & Western and the Virginian Railway—and of Henry Ford for the Detroit and Ironton on electric locomotive design and application, assures a continuation of development for the future requirements of our American railroads.

Transformer and Screen for Testing Locomotive Headlights

By James C. Moore
Chicago, Rock Island & Pacific Railway Company, Eldon, Mo.

When it is necessary to test out the wiring on a locomotive which is cold or has insufficient steam for the turbine, the method used in the Rock Island roundhouse at Eldon, Mo., is to disconnect the wires from the turbine and in place of the turbine connect a small transformer of about 500 watts capacity, which receives power from the A. C. lighting circuit.

The transformer core was built from laminations taken from a discarded service transformer. It has four sides,



The Screen Which Is Hung on the Wall of the Roundhouse About Twelve Feet from the Locomotive Headlight

each rectangular in section. Each side is 1 in. by 2 in. in cross section and the outside dimensions of the assembled core are 6 in. by 10 in.

In making the transformer, three sides were first assembled and then the opposite sides wound; 320 turns of No. 18 double cotton covered wire were used on the primary and the secondary was wound with 95 turns of No. 10 wire. After the two windings were put on, the fourth side of the core was built up in place and the whole encased in a wooden framework.

The transformer is connected, when in use, to the 115-volt alternating current shop supply circuit by means of an extension light cord and plug. The wooden framework around the transformer prevents the possibility of a short circuit on the locomotive jacket. The primary winding is provided with a small gap across which a piece of 6-amps. fuse wire is fastened. The secondary is provided with an Edison type fuse block fitted with 15-amp. fuse plugs.

One of the most common uses this transformer is put to is to light the headlight while it is being focused. A large screen, made of canvas, on which is painted a single perpendicular line and several horizontal ones, is placed in front of the locomotive and the headlight lamp is lighted from the secondary of the transformer. The screen is placed on the roundhouse wall just in front of the locomotive. The headlight lamp socket is turned and raised or lowered until a perfect circle of light shows on the screen. This is then adjusted for height by adjutsing the position of the headlight case.

Quick Method for Erecting Transmission Towers

A unique method of setting transmission line towers has been adopted by the Illinois Power & Light Corporation.

The line which will extend from the power dam at Keokuk, Iowa, to Galesburg, Ill., will contain 600 towers, each of which is 65 feet high. The line will be 75 miles long and the construction cost is estimated at $1,250,000.

The method of erecting the towers consists of a new scheme for securing the feet. A hole 8 feet deep and 5½ in. in diameter will be drilled where each leg of a tower is to stand. Dynamite will then be lowered into the hole and touched off, blowing a cavity at the bottom 2 feet in diameter. Concrete will be poured into the cavity and the legs of the tower set into it. After the concrete hardens, the tower legs will be anchored in solid balls of stone imbedded in the walls of earth compressed by the exploded dynamite.

Making Friends

"If a man does not make new acquaintances as he advances through life, he will soon find himself alone. A man should keep his friendships in constant repair." This was the belief of Dr. Samuel Johnson, and is just as true today as when he said it.

What can be of more satisfaction to a human being than the knowledge that he enjoys the real friendship of worth-while people. This does not mean that your friends are to be numbered only among those who possess wealth or even influence, but rather let them be the sort that can extend the hand of sympathy when needed.

In the first place, does it not seem desirable that we should provide companionship for old age so we will not

feel alone and deserted? Again, why not enjoy these friendships while passing along the path of life?

Now, here is a practical suggestion with regard to making a start. For instance, when you are introduced to a person who could be of assistance to you, do not content yourself by letting him get no more of an impression of your personality than the usual "glad to meet you," but make an effort to carry on an intelligent conversation sufficient to give that person a definite impression of your name and your personality.

Nobody Home

"Where's the president of this railroad?" asked the man who called at the general offices.

"He's down in Washington, attendin' in the session of some kind uv an investigatin' committee," replied the office boy.

"Where is the general manager?"

"He's appearin' before th' interstate commerce commission."

"Well, where's the general superintendent?"

"He's at th' meetin' of th' Legislature, fighting some bum new law."

"Where is the head of the legal department?"

"He's in court tryin' a suit."

"Then where is the general passenger agent?"

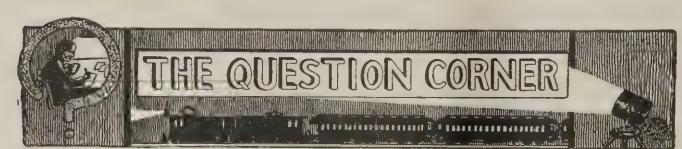
"He's explaining to the commercial travelers why we can't reduce the fare."

"Where is the general freight agent?"

"He's gone out in th' country t' attend a meeting of th' grange an' tell th' farmers why we ain't got no freight cars."

"Who's running the blamed railroad, anyway?"

"Th' newspapers and th' Legislatures."—*Pittsburg Press.*



Answers to Questions

1. *What is the first thing to be done when a generator refuses to motor?—H. H.*

2. *What is the best method of procedure in order to bring a cell that has dropped in voltage, up to correspond with the others of a set?—H. W.*

3. *Do temperature changes affect battery capacity and how?—M. G.*

When the Generator Will Not Motor

If the generator of a car lighting equipment will not motor it indicates there is trouble either with the generator armature circuit or the field circuit or both. It can be quickly determined whether the trouble is with the armature or the field by opening a connection in the field circuit with the automatic switch closed. If a heavy spark is observed the field circuit is o.k. but if there is no spark the generator field circuit is open. If the trouble is in the armature circuit there will be no spark on opening the automatic switch, provided the connection of the field circuit just mentioned is left open.

The connection on the board should be followed out carefully to see that the fuses are o.k. and that there are no loose connections. Take a look also at the generator field rheostat if the trouble is in the field circuit. Look over the generator leads carefully to see that none of them are broken and open the generator and inspect the brushes to make sure that they make good contact on the commutator. If the trouble is in the generator fields, test them out with a voltmeter; the coil across which the voltage indication is abnormally high will indicate an open circuit.

Charging One Cell in a Battery

It is sometimes necessary to charge one cell of a battery separately from the others, but it is not always convenient to charge this from the charging plant. Even if this is done, however, there is a great waste of energy in the resistances placed in series with the cell.

A simple way of doing this is to disconnect the terminals of that particular cell from the rest of the battery and attach leads long enough to reach any of the other cells in the battery. By connecting these leads to the outside terminals of the twin cell tank, positive to positive and negative to negative, current will be supplied by these two cells in series to charge the low cell. This would furnish about 4 volts at the terminals of the lower cell which would be entirely too high so a resistance of sufficient current capacity such as a piece of iron wire should be inserted to keep the current down to normal.

In charging the low battery, the other two cells are of course, discharged, so the connections should be changed during the charge, shifting from tray to tray so that no particular pair of cells will be overworked in bringing up the low cell. Before attempting to charge a low cell in this way it is advisable to seek out and remove the cause for its being low. The condition may have been brought about by short circuits or impurities in the electrolyte.

Change in Capacity with Temperature

When a battery is rated at 300 ampere-hours it means that it will give 300 ampere-hours when discharged at the 8 hour rate. The end of discharge is determined by the voltage falling off to 1.8 volts. There is, of course, a considerable number of ampere-hours capacity still remaining in the battery, but it is not considered advisable to discharge it below this voltage. Voltage is then the limiting factor in determining battery capacity.

In cold weather, if the discharge rate be high there will be a rapid falling off in voltage, due to the sluggishness of the cold battery, so that the voltage of 1.8 volts per cell will be reached sooner than it ordinarily would at normal temperature. The full battery capacity may be in the battery, however, but on account of the falling off in voltage this capacity may not be available at the normal current rate.

If the battery is discharged at low current rates, however, the discharge voltage will not be appreciably affected by the low temperature and the battery will give its full capacity. This may or may not be the total rated capacity of the battery, depending upon its condition.

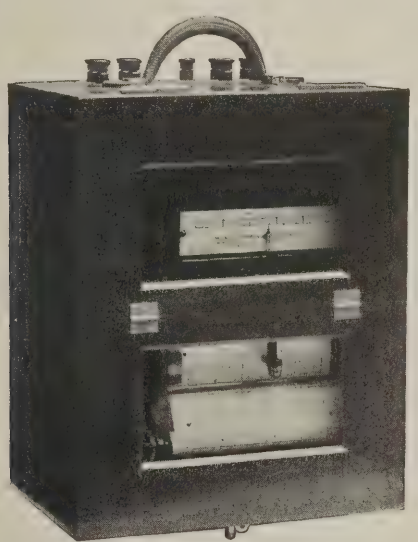
Questions for July

I have an induction motor of the following construction; Stator, 3 circuit, delta; Slots 180; pitch 1 to 12; conductors 6 per slot; Rotor 1 circuit Y; Slots 142; Slip 5 per cent; conductors 2 per slot; R. P. M. full load 585. I would like to secure the following information,—What is the secondary voltage when the rotor is locked? When rotor is not locked and starting up on light load? When starting up with heavy load? How would a person go about a test to obtain this data?—C. T. G.

NEW DEVICES

Portable Recording Instruments

Among the recent developments by the Westinghouse Electric & Manufacturing Company is a new portable recording instrument known as Type R. It is made for applications where records as accurate and reliable as those obtained with large switchboard instruments are



Type R Three Phase Portable Recording Wattmeter

necessary. Such applications include analysis of motor operation, typical consumption curves of large industrial consumers, and records of power distribution.

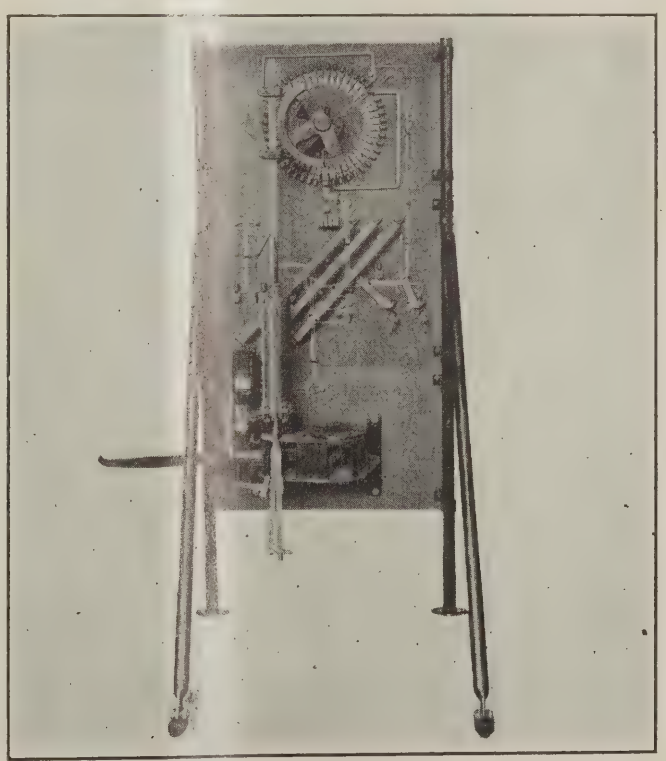
The Type R instrument is an adaptation of the switchboard recording instrument, with the element as a whole mounted in a portable carrying case. An electric self-winding clock is used for speeds up to 24 inches per hour. For slower speeds, up to four inches per hour, a hand-wound clock can be used.

Alternating current ammeters, alternating and direct current voltmeters, and single and polyphase wattmeters are made in these portable recording instruments.

Pressure Controlled Speed Regulating Panel

The General Electric Company is now marketing a new and improved type of pressure controlled speed regulating panel for automatically governing boiler steam pressure by the control of the speed of the motor-driven forced draft blower. This new device is known as the CR-7731-A1, and is similar to the type which it supersedes, with the exception of a notching attachment, furnishing a definite graduated movement of the motor controller

The previous type panel incorporated a compensating feature requiring a continued increase or decrease in pressure to move the controller through its entire range. In addition to this feature, the new type has a pilot valve controlling the movement of the main plunger which, in turn, moves the pilot valve back to a neutral or cut-off



Rear View of Panel

position, at each of a series of definite or stepped positions. At the same time, a counteracting force is applied to the scale beam which requires a new pressure valve to be set up before the pilot valve will again operate. This gives a step-by-step action to the motor controlling switch which has a number of points corresponding to the number of notches provided on the pressure regulator.

Inspection Tube for Oil Circuit Breakers

For the purpose of readily determining the condition existing inside the tanks of large oil circuit breakers without the necessity of emptying the oil, the Westinghouse Electric and Manufacturing Company has perfected a sight tube, built on the principle of the periscope and so designed that the contacts of the breaker can be easily inspected by the operator from a position outside the tank. The use of this sight tube saves a great deal of time formerly wasted in emptying the oil out of the breaker tank, which with a 2800 gallon tank often required almost half a day. Breaker contacts can be inspected with the new device in 15 minutes, a valuable saving when the breaker is on an important line.

Periscope Used to Examine Contacts of Large Oil Circuit Breakers

The new tube, which is built in the same manner as an ordinary "stove pipe" periscope, is extremely simple in construction and operation. At the end of the tube, in a bulb shaped compartment, a 100 watt, 110 volt lamp is placed so that its rays illuminate the area in front of the lower sighting hole of the tube. A circular mirror, directly above this lamp and opposite a glass covered opening in the tube, is placed at an angle of 45 degrees to the perpendicular axis of the tube so that it reflects an image of whatever is illuminated by the lamp.

When a breaker is to be inspected, the operator removes the manhole in the cover and lowers the sight tube into the tank, first making a connection for the electric light. By careful manipulation of the tube, the operator can then inspect the contacts and other working parts of the breaker and determine whether or not draining the tank is necessary.

The tube is built in three lengths, 5 feet 3 inches, 6 feet 2 inches, and 6 feet 7 inches, depending on the size of the breaker tank.

Portable Mechanical Painting Equipment

As the result of several years of development work, the W. N. Matthews Corporation, St. Louis, Mo., has recently placed on the market a portable apparatus for mechanical painting. Care has been taken in the design of this equipment to see that there is a continuous supply of air at a uniform pressure, free from moisture and oil. These units have been designed to handle a wide variety of materials, such as lead and oil or ready mixed paints, mill whites, stains, varnishes, lacquers, enamels and shellac.

In order to meet different working conditions, this company manufactures various types of equipment. Each type consists essentially of an air compressor that is operated by an internal combustion engine, or an electric motor. There is also an air storage reservoir and the necessary paint pots, hose and guns. The assembled unit, consisting of the compressor, driving unit and reservoir, may be mounted upon a portable hand truck, or on a standard truck chassis of the Ford or Chevrolet design.

The illustration, Fig. 1, shows the portable engine-driven equipment with a water-cooled compressor of the vertical type, fitted with feather valves. The compressor has a capacity of approximately 15 cu. ft. of free air per minute. Special attention has been given to the system of lubrication so as to reduce to a minimum the oil content of the air. In addition to having a safety valve on the air reservoir, there is also an automatic unloader on the compressor to remove the load when the demand for air is less than the amount delivered. The equipment and truck, as shown in the illustration, weighs 1,075 lb.

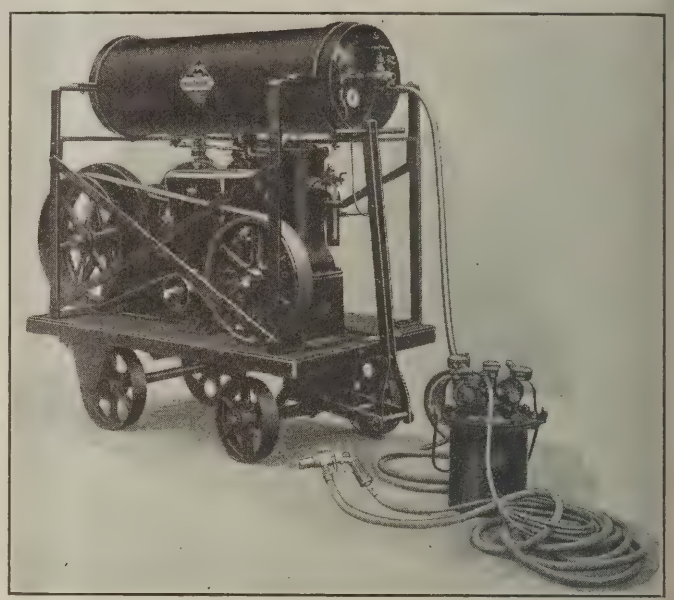


Fig. 1—This Equipment Is Driven by an Internal Combustion Engine and Has Sufficient Capacity for Two Guns

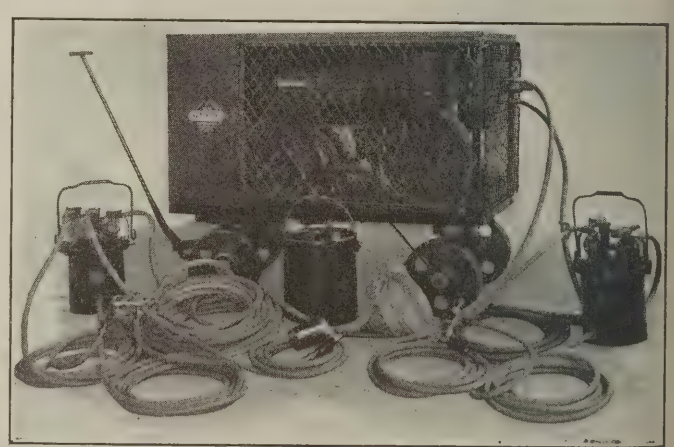


Fig. 2—The Electric Motor Driven Unit Also Is Compact and Easily Handled

The horizontal engine is of the single cylinder, four-cycle type, equipped with a water reservoir for cooling, and develops three horsepower. It can operate on either gasoline or kerosene. A belt drive is used between the engine and the compressor to secure proper weight distri-

bution and also to eliminate vibration when it is operated. The electrically operated units, Fig. 2, are practically of the same design, except that a motor is substituted for the engine. If the equipment is mounted upon an automobile chassis, the engine and compressor are direct connected. This provides a simple driving mechanism.

The material container, or paint pot, is equipped with a filling plug, air release cock, safety valve and two diaphragm regulators with gages. One regulator controls the pressure on the material in the pot and the other governs the air supply to the gun. Two containers are

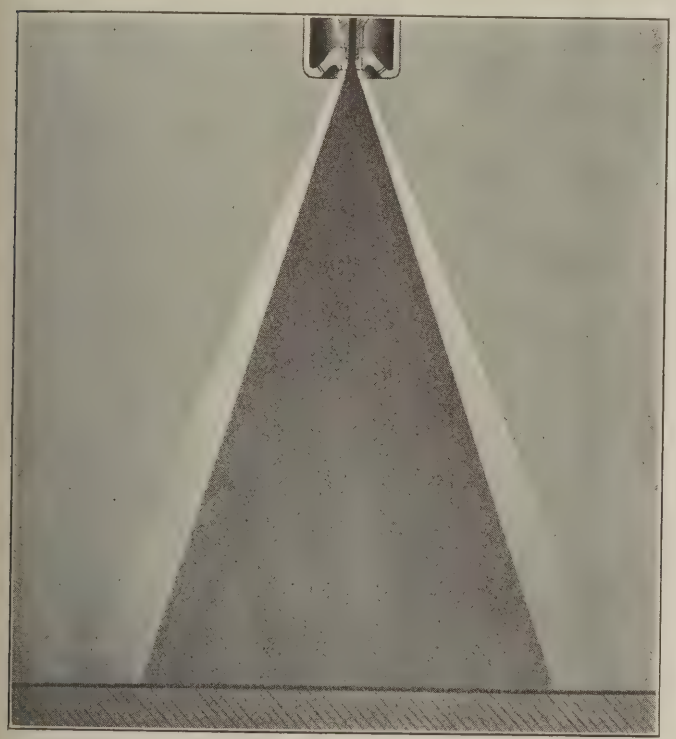


Fig. 3—The Paint Cone Is Surrounded by an Envelope of Free Air

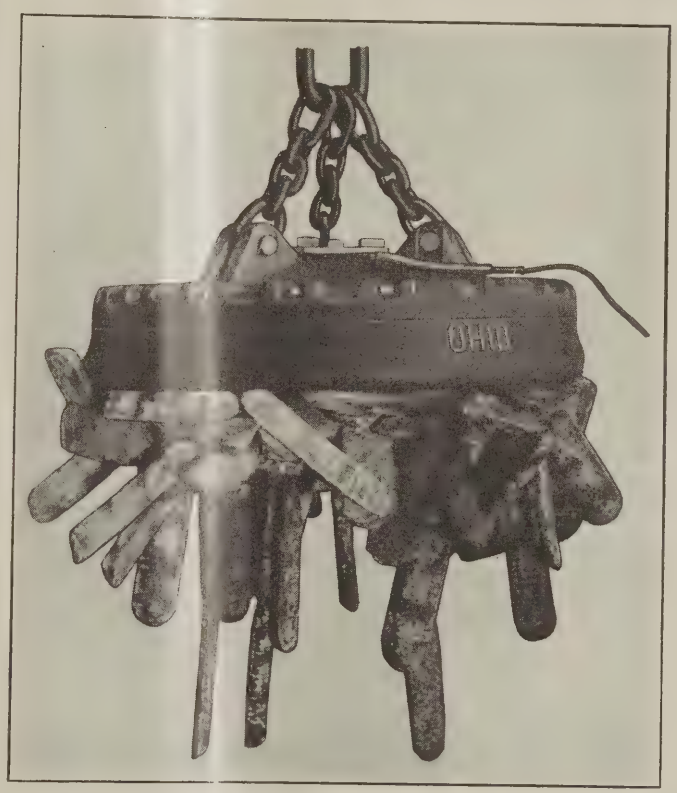
furnished, one of 2½ gallons and another of 12½ gallons capacity.

The gun shown in Fig. 1 will handle materials ranging from cold water paints up to and including those with an asphaltum base. By adjusting the sleeve at the nozzle, it will deliver a flat or fan-shaped strip with a width from 10 in. to 12 in., or a cone of about 8 in. in diameter. The gun is designed to effect contact between the air and the paint only at the extreme end of the nozzle. This tends to produce perfect atomization of the material. An outstanding feature of the gun is the air envelope that surrounds the paint cone, as shown in Fig. 3. The free air in the envelope travels faster than the air in the cone that is laden with paint and the result is that practically the entire quantity of material is delivered against the surface to be painted, while comparatively little escapes into the air as mist. This produces an economy in the consumption of material, with a cleanliness in operation that equals ordinary brush work. This equipment has sufficient capacity for the steady operation of two of these guns.

Heavy Duty Lifting Magnet

A lifting magnet adaptable for heavy work around a foundry, store house, scrap yard or a metal yard has been added to its line of electrical products by The Ohio Electric & Controller Company, Cleveland, Ohio. It is identical in construction with 45-in. and 55 in. magnets manufactured by the same company, except that the center pole is held in place by three 2-in. studs which replace the center pole supported by a single large bolt cast into the magnet.

Difficulty has been experienced with the smaller magnets from accumulations of carbon dust on the terminal insulator which caused flash overs to ground and left a carbon path which eventually led to a permanent grounding and ruined the insulator. This has been overcome on the 65-in. magnet by placing a heavy insulator around the outside connection and terminal. The coil is brought into contact with the top and bottom of the case on surfaces large enough to conduct the heat to the outside of the case and radiate it to the atmosphere. It is said that the magnet on the outside seldom reaches a temperature of more than 40 deg. C. The coil itself, measured by the increase in resistance method, seldom goes above 80 deg. C. The result of this protection is a high average current which gives the magnet high all day average lifting



The Center Pole Is Held in Place by Three 2-in Studs

capacity which provides efficient and economical operation at any time.

The center pole is held in place by three 2-in. diameter studs which are made of 3½ per cent nickel steel. The cap bolts which hold the bottom ring in place are also made of 3½ per cent nickel steel. This feature tends to reduce the wear to a minimum.

The illustration shows the magnet lifting 5,200 lb. of pig iron. This load was greater than the average capacity because the magnet was cold. The average lifting load for all day service is about 4,000 lb., which can be handled without injurious heating.

General News Section

The Safety Car Heating & Lighting Company has removed its Chicago office from the Peoples Gas building to the new Straus building, 310 South Michigan avenue.

The Ramsey Chain Company, Inc., Albany, N. Y., has appointed the Morse Engineering Company, 549 West Washington street, Chicago, as the company's Chicago representatives.

Gisholt Machine Company, Madison, Wis., has purchased the business of the Milholland Machine Company at Indianapolis and will continue to manufacture the Milholland machines at Madison, Wis.

The Economy Fuse & Mfg. Company, Chicago, Illinois, announces the appointment of Morgan P. Ellis as General Sales Manager. Mr. Ellis has been Assistant General Sales Manager for the past eight years.

The Okonite Company, Passaic, N. J., announces the appointment of George N. Brown as manager of the company's Atlanta office. Mr. Brown succeeds J. L. Phillips, who has been appointed manager of the San Francisco office.

Rome Wire Company announces the opening of a sales office with complete warehouse for its products at the Ninth street terminal warehouse, 1200 West Ninth street, Cleveland, Ohio. C. R. Evans will be the district manager.

The Japanese Government Railways have ordered two 93-ton electric locomotives and six 70-ton electric locomotives. The locomotives will be built by the Baldwin Locomotive Works and the electric equipment supplied by the Westinghouse Electric & Manufacturing Co.

The Temiskaming & Northern Ontario has ordered from the Railway Storage Battery Car Co., through its Montreal representatives, the International Equipment Company, Ltd., one 55 ft. combination passenger, smoking and baggage storage battery car. The car is to be equipped with Edison batteries, General Electric motors and control, and Westinghouse air brake equipment.

The Gibb Instrument Company, Bay City, Mich., on July 1 placed W. F. Hebard & Company, 551 W. Van Buren street, in charge of its Chicago office. Thomas Barnes will head the welding department and will be assisted by Charles Watson. E. S. Hurd, who represented the Gibb Instrument Company in Chicago for the past 5 years has been transferred to the New England territory, effective August 1.

The Atchison, Topeka and Santa Fe Railway System recently placed an order for twenty-eight arc welding equipments with the Westinghouse Electric & Manufacturing Company. These equipments will be distributed among fourteen shops, from Chicago to the Pacific Coast. This order, one of the largest ever placed for welding equipment, is renewed evidence of the activity of the railroads in extending their welding facilities, and proof of the economy that results from an extensive use of electric arc welding in railway shops.

The Continuous Train Control Corporation has been incorporated at Detroit, Mich., for $1,000,000 for the manufacture of train control devices and electrical and mechanical devices. The new company will operate under the Clark patents and is now perfecting refinements of the established principles of the system in connection with a test installation. W. S. Kinnear, of W. S. Kinnear & Company, engineers, New York, is president of the new company and T. E. Clark is consulting engineer. Others associated with the company are T. C. Fogel, F. R. Bissell and S. D. Cushing.

The Oliver Electric & Manufacturing Company, St. Louis, Mo., has effected a reciprocal selling arrangement with the Pyle-National Company, Chicago, and will continue under its present management, manufacturing a complete line of locomotive wiring fittings for electrical installation on a locomotive in conjunction with the Pyle-National turbo-generator and headlight cases; passenger car fittings and train connectors to complete electrical installation on passenger cars in conjunction with the Pyle-National head end lighting equipments for suburban and branch line trains; weatherproof switches, plugs, and receptacles, junction boxes, etc., to complete installation of flood lighting as well as manufacturing numerous other electrical appliances for use in roundhouses, shops, buildings, etc.

The Chain Belt Co., Milwaukee, Wis., announce the election of J. C. Merwin, formerly works manager to the position of second vice-president at the annual meeting of the company held in Milwaukee, last month. Mr. Merwin is a graduate of Sheffield Scientific School, Yale University (1910), and has been associated with the company since 1917. Other new officers elected were—Brinton Welser as secretary, and C. E. Stone, as assistant secretary. Mr. Welser is a graduate of the University of Wisconsin (1912) and has been with the Chain Belt Company in various capacities ever since. Mr. Stone is assistant to the president, and has also been purchasing agent since 1918. He is a graduate of the University of Michigan (1910). The officers re-elected were C. R. Messinger, President, Clifford F. Messinger, First Vice-President, C. L. Pfeifer, Treasurer.

Long Island R. R. Electrification Under Way

Actual work in connection with the Long Island Railroad's plans to electrify its double-track line between Jamaica and Babylon—a distance of twenty-eight miles has begun with the installation of long ties, which are used for holding the third rail. Over 30,000 of these ties have been ordered, and they are now being delivered in large quantities.

Third rail orders have been placed to the extent of

about 6,000 tons, and a substantial tonnage has already been shipped from the steel mills. Jumper cable and conduits to be used at street crossings, third rail insulators, protection board and fittings, and other necessary third rail material has been ordered, including about 37,000 track rail bonds. Early deliveries have been promised by the manufacturers.

All poles, cross-arms and fittings for transmission lines, have been ordered. Some of this material has been received and other consignments are now in transit.

Equipment for the six power sub-stations to be erected at Laurelton, Lynbrook, Freeport, Wantagh, Amityville and Babylon, has been ordered, and the construction of these buildings will commence in the near future.

Signaling equipment required for changing the present signal system on the Montauk Division to Babylon, has been ordered.

With the exception of the sub-station buildings proper, the work will be carried on by the company's own construction forces.

While the work of putting in long ties on which the third rail will rest is going on, the roadbed will be torn up and consequently more or less dusty. As soon as ties are in, the oil train will follow and lay the dust for the summer.

Detroit & Ironton Electrification

Visible evidence of progress toward electrification of the Detroit & Ironton Railroad may be seen in the Rouge erecting shops according to the last issue of the Detroit, Toledo & Ironton Railroad News.

Nearly all parts to be used in assembly of the first locomotive are in readiness and the construction will begin probably not later than the middle of July. The locomotive will be 117 ft. long, of the 0-8-8+8-8-0 type. There will be a motor for each of the 16 driving axles. The total weight of the locomotive will be 340 tons and the maximum tractive effort 200,000 lb. The first of the eight turbines which will furnish power for the electrification has passed successful operating tests. It will generate 62,500 hp. A 23,000-volt alternating trolley will be used in conjunction with low voltage motors operating on 600 volts direct current. Metal forms are being made at the present time to be used for casting the concrete catenary supports.

Electric Storage Battery Co. to Erect New Building

The Electric Storage Battery Company, has purchased a tract of 130,001 square feet from the Chicago Title and Trust Company, for building. The first unit will cover the southern half of the property with a two story front and one story rear extending to the railroad and will contain about 75,000 square feet floor space. The northern half of the plant will be built as increasing business warrants. This building will serve as the company's Chicago factory branch, depot and service station which activity is now centered in their building in Thirty-fifth street and Shields avenue which they have occupied for fifteen years. The factory staff and some of the executive departments will be moved to the second story offices of the new building. The sales department of the company, however, will remain in the Marquette Building, the downtown location of the company for the past 25 years.

Pennsylvania Asks Test of Its Train Control

President Rea, of the Pennsylvania, has filed a petition with the Interstate Commerce Commission asking that the commission make an inspection and test of the automatic train control apparatus installed on its Lewistown division, 49 miles, to the end that the device may be formally approved by the commission before the company is required to proceed at great expense with the installation of similar devices upon other parts of its road as required by the commission's orders of June 13, 1922, and January 14, 1924. The petition also asks an extension of time in which to make the installations designated, in the event that the device installed on the Lewistown division is formally approved, on the ground that it will be physically impossible to complete the installations within the time fixed and that, because of the excessive cost, such installations should be spread over a greater period of time.

The company has expended approximately $350,000 on the Lewistown division installation, the petition says, and the device has been in actual service for all trains over the division since July 11, 1923. The company had requested the commission to inspect and test the installation, both by letter and by petition, but the petition was formally denied on September 26, 1923. The company is now engaged in developing the device, the petition says, and submits that it should be inspected, not only in justice to the petitioner but for the information of the commission with a view to the development of the art of train control.

The company estimates the cost of equipping all its lines with the induction type of train control, which it believes to be the only safe and practical one, at $115,000,000; the cost for its line from Baltimore to Harrisburg at $1,758,679, and for the West Jersey & Seashore between Camden and Atlantic City at $1,077,503.

C. P. R. Considers Possibility of Electrification in the Rockies

President E. W. Beatty, of the Canadian Pacific Railway, who with four or five of the road's directors, recently made a tour of inspection of the system, announced in Vancouver that serious thought was being given to electrification of the mountain division of that road. Experts are making a careful examination of the possibilities of such a change in the Rockies, said Mr. Beatty, and when their report is complete it will remain with the heads of the road to consider whether or not the cost would justify the change. He believes that electrification might greatly reduce the cost of haulage through the mountains and he made it clear that his road had its eye on the steadily increasing westward flow of grain from Alberta to Vancouver and also on the fact that the Canadian National in its more northerly pass through the mountains has very much easier gradients than the C. P. R. Reference was made to the results obtained by electrification on the Chicago, Milwaukee & St. Paul.

Safety on the C. & N. W.

The Chicago & North Western has preached and practiced safety 13½ years. Members of the safety committees have made 73,405 recommendations for the elimination of dangerous conditions and practices and all but 3,132 have been adopted and put into effect. During this period 617 fewer employees were killed than in the previ-

ous 13½ years (ending June 30, 1910), a decrease of 42.49 per cent; 32,464 fewer employees were injured, a decrease of 27.81 per cent; 23 fewer passengers were killed, a decrease of 15.7 per cent; 3,065 fewer passengers were injured, a decrease of 24.4 per cent; 917 fewer outsiders were killed, a decrease of 28.72 per cent and 663 fewer outsiders were injured, a decrease of 8.05 per cent. During 1910 the total of ton miles of freight moved by this road was 5,515,535,840, compared with 9,248,615,383 in 1923; while 97 employees were killed and 8,404 were injured in 1910 as compared with 38 killed and 6,135 injured in 1923. The tons carried one mile for each employee killed increased from 56,861,195 in 1910 to 243,384,615 in 1923; an increase of 328 per cent in the chances of safety to the individual. Safety banners for the best work in accident prevention during 1923 were awarded to the Eastern division, the Missouri Valley shops and the Milwaukee Terminal safety committees.

Personals

Benjamin G. Lamme, chief engineer of the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., and a well-known electrical genius and inventor, died on July 8 at East Liberty, Pa., after an illness of several months. Mr. Lamme was born 60 years ago on a farm near Springfield, Ohio, and pioneered in the field of electricity when text books were almost unknown; he designed many of the standard types of generators and motors in use today. He became associated with the Westinghouse interests in their infancy and for many years served as chief engineer. About 150 inventions are reported to Mr. Lamme, including the umbrella type generator, used at Niagara Falls, the high tension system of power transmission and the synchronous converter, employed notably on the subway systems of New York for changing alternating to direct current. His conception of the single phase alternating current now in use on street cars and long electric transit systems revolutionized the industry in the early nineties. Mr. Lamme recently designed a 62,500 kw. generator, the largest ever built. Last year he was cited by Ohio State University as the greatest living mathematician, an honor which previously had been bestowed only twice, upon Mr. Edison and Mr. Steinmetz. As a student of Ohio State, Mr. Lamme was a prodigy of mathematics and a youthful master of high-range multiplication tables and differential calculus, who discovered many short cuts in mental calculation. This latter was of great help to him later on in life, as most of his inventions were products of intricate calculation and great imagination. Mr. Lamme's researches were largely confined to the industrial field and were devoted to the solution of power problems in big units. He designed the generating and motor equipment for the first big railway electrification, that of the New York, New Haven & Hartford railroad. He received the highest honor from the American Institute of Electrical Engineers, having been awarded the Edison medal in 1919. He served as one of the two members of that body on the Naval Consulting Board during the war, and was made chairman of the invention committee of the board.

B. G. Lamme

Beverly L. Worden, vice-president of the Cutler-Hammer Manufacturing Company, Milwaukee, Wis., has been elected president to succeed Frank R. Bacon, who has been elected chairman of the board of directors. Mr. Worden was born at Chicago on February 8, 1871, and graduated from the University of Wisconsin in 1892. In the same year he entered the employ of the Wisconsin Bridge & Iron Company, Milwaukee, Wis., where he was employed in various capacities until 1902. He resigned from the Wisconsin Bridge & Iron Company on that date to become associated with the Worden-Allen Company, Milwaukee. In 1912 he founded the Lackawanna Bridge Company, Buffalo, N. Y., but still retained the presidency of the Worden-Allen Company. A few years later he purchased the Ferguson Steel & Iron Corporation, Buffalo, N. Y. In 1917 Mr. Worden was in charge of the construction of the Submarine Boat Corporation's shipyards at Newark, N. J., and later directed the construction of 150 steel ships for war emergency use. He is still connected with the Submarine Boat Corporation. In 1922 he became president of the Beaver Board Company, an affiliated company, and still holds that position. He became vice-president of the Cutler-Hammer Manufacturing Company in March, 1923, which position he has held until his recent promotion.

B. L. Worden

M. E. Diebert, foreman electrician at Russell, Ky., on the Chesapeake & Ohio Railroad, has returned to the larger shop of Clifton Forge, Va., where he will be engaged in the same capacity.

Frank Nelson, electrician at Newport News, Va., on the Chesapeake & Ohio, was recently promoted to the position of foreman electrician at Russell, Ky.

Philip S. Westcott, formerly assistant car lighting engineer of the Chicago, Milwaukee & St. Paul, with headquarters at Chicago, has been appointed special representative for the Pyle-National Company, with headquarters at Chicago.

K. A. Hills, representative of the General Electric Company at Davenport, Ia., has been promoted to manager, with the same headquarters. S. E. Gates, manager of the Spokane, Wash., office, has been transferred to Los Angeles, Cal., and will be succeeded by Bernhard Olsen.

Railway Electrical Engineer

Volume 15 AUGUST, 1924 No. 8

Purchased Electric Power

The use of machinery driven by electric power and the use of electric light have during recent years rapidly increased the electric power consumption of all railroads. The corresponding demand for power supply has been met efficiently in a few cases and has been complied with in a haphazard fashion in many others due to the urgent need for immediately increasing power facilities. In the majority of the cases where more power is required the question arises as to whether the power should be purchased or generated.

Relatively few railroads have a highly developed organization for the purpose of manufacturing power. In addition to this, very large power plants and power net works have enabled the utility companies to produce power to better advantage than is possible in the average railroad power plant. The natural result is that there is an ever increasing amount of power purchased each year from power companies. In turn there has arisen a need for developing a form of power contract best suited to the requirements of the railroad purchaser. Such a contract is suggested in an article published elsewhere in this issue under the title, "Contracting for Electric Power Service." Features of the suggested plan for purchasing power may be impracticable as it has the elements of the cost plus contract which might give the power producer such a sense of security that he would not exert his best effort to produce power at the lowest possible cost. On the other hand, with exigencies properly allowed for, the suggested form of contract would make it possible for the producer to keep abreast of the times in the science of power generation. The result of this would be that dependability of the power supply would be assured, excess profits to the producer would be avoided and the cost to the railroad kept at a minimum. In view of these possible savings and improvements, the plan is worthy of consideration and the author will welcome suggestions and criticisms.

Generated Electric Power

The preceding editorial entitled, "Purchased Electric Power," attempts to indicate present day demands and tendencies in the railroad field as regards power supply. A notable exception to the tendency to buy more power is shown by the Missouri-Kansas-Texas power plant described elsewhere in this issue. This plant provides a railroad terminal with air, water, steam and electricity and generates the electric power at a generating cost as low as can be obtained by the great majority of public service corporations. The plant is an exception as a railroad power plant but there are undoubtedly many roads that could make large savings by improving their own power plants or building new ones.

The power cost figures of the Katy plant show a monthly saving of from $5,000 to $9,000 as compared with the cost of power generated in the old plant. Probably there are relatively few localities in which such large savings could be effected, as in the location described the demand for electric power is relatively large and there is also a good demand for low pressure or exhaust steam. The costs given compare the new plant with an old one using non-condensing engines, but the old plant was probably not less efficient than the average railroad power plant. The plant described is a model plant and contains features which can be used to excellent advantage in the power plants of many railroads which are striving to meet the ever increasing demand for more electric power for shop operation and lighting.

Possibilities of Rail Motor Cars

Probably there has been nothing more effective in reducing the cost of operation on certain branch lines than the growing adoption of rail motor cars. Certainly it cannot be claimed that rail motor cars are of recent origin, for a limited number have been in service at one time or another on different roads for a long time and have rendered excellent service. As with all other kinds of motive power, the rail motor car has passed its various stages of development until today the service rendered by this type of equipment is of high quality. The recent trip made by one of these cars between Chicago and Atlantic City at record speed clearly indicates what may be expected of them in the future. Not only was this long journey accomplished in remarkable running time but not the least difficulty was experienced with the equipment throughout the trip.

Manufacturers of these cars have gradually built into their design all that is best in automobile practice and at the same time have kept ever in mind conditions and requirements for steam railroad operation. The result is that better cars are being constructed today than ever before and the indications are that improvements along this line will still continue for some time. The ultimate result is certain to be a very high grade car of maximum dependability which can be operated at a cost which will be very small as compared with the cost of steam equipment for the same service.

Importance of Fuses

Fuses are placed in circuits for the protection of the wiring and the apparatus connected to it. Anything which permits the integrity of the fuse to be violated immediately introduces a condition which is bound to result in injury to the wiring or equipment. It is very probable that most of the fuse tinkering or doctoring is done by those who do not appreciate the seriousness of what they are doing although there are, no doubt, instances where such practices are carried on by persons who know better, but who have no scruples about taking a chance. There are two ways in which decided improvement can be effected in the matter of improper fusing. One of these is to have fuses locked up so that they can only be replaced by some responsible person who realizes the necessity for putting in a fuse of the correct capacity. The second way is to inaugurate some form of educational campaign among those who insist upon using equipment, such as motors, beyond their rated capacity. If these two methods are carried out, it will go a long way towards cutting down the number of armature burn-outs and the resulting expensive delays to production.

Oil Engines for Traction

The future possibilities of Diesel or Semi-Diesel engines for propelling cars and locomotives have long been a matter of much speculation on the part of traction engineers. Originally the Diesel engine was not dependable; a person not especially skilled and trained could not be relied upon to keep the engine in continuous operation. The potentialities of this kind of prime mover with its great fuel economy have been sufficient, however, to have Diesel internal combustion locomotives considered seriously for the solution of such problems as that presented by the Illinois Central lines in the Chicago district.

In Sweden, automobile competition has caused increased use of internal combustion engines by the railroads, particularly those of the Diesel type, and the shorter local passenger lines, mostly privately owned, are now rapidly being transformed to motorized train service. The first Diesel motorized train was installed in September, 1913, and at the present time there are about 15 of these trains in operation on the Swedish lines.

The oil-electric locomotive now being used in switching service in New York City by the New York Central, probably presents the most important application of this type of prime mover for traction purposes in this country. This locomotive was described in the June, 1921, issue of the *Railway Electrical Engineer,* page 183. One of the shortcomings of the Diesel engine is that it does not idle well. This difficulty is entirely overcome in the case of the oil engine used on the New York Central locomotive. Another handicap of the original Diesel engines was their weight, but the engine on the Central locomotive weighs only 56 lb. per horsepower, which leaves a wide margin in which to add any such weight as may be necessary for electrical equipment. Dependability and maintenance charges are factors which have to be determined, but six months' service indicates that the engine can be relied upon and that the maintenance costs will be small. If fuel costs were the only factor, both steam and electric locomotives would be rapidly superseded. The oil-electric switching locomotive is equipped with a 300-hp. engine. This is small power for a locomotive, but in this class of service high speeds are not required and the characteristics of the electric drive are such that the full power of the engine can be applied to the rails at any speed. As a result the locomotive gives excellent performance as a switching locomotive. If larger locomotives are built, it will mean that they must be equipped with more than one engine or with a larger engine. This will be a matter of development, but apparently it presents no insurmountable difficulties. The characteristics of the locomotive conform with the service requirements of general switching practice and it is entirely possible that further development will give the locomotive a wider field of usefulness. Only time will show the extent of its application.

Letter to the Editor

Should Railroads Purchase Power?

To the Editor:

I have noted with interest Mr. J. R. Sloan's comments on your editorial "Should the Railroads Purchase Power?"

Mr. Sloan brings out some valuable points, and it is of especial interest to note that his experience has been that where steam is required throughout the year the cost of purchased power is usually greater than that of power produced by railroads.

As has been truly said, each individual instance must necessarily be subject to careful analysis, but the following points, which Mr. Sloan has not mentioned specifically, may be of interest in this connection.

The ordinary small engine running non-condensing is very wasteful of steam, and even though it may be possible to use the exhaust steam for heating, the demands for heat and those for light and power usually occur at different periods of the day and vary with the seasons. This diversity factor often means that much steam necessarily is exhausted into the atmosphere, and such exhaust means real money. This, especially where coal is perhaps more expensive than is the case on the Pennsylvania System, often offsets the advantages obtained in local power production.

The engines, generators, switchboards, etc., mean, of course, a capital investment, and to this must be added in many cases additional boiler capacity required on account of power production. The fixed charges of all these facilities, of course, enter into the cost of power, and where the plant is a small one the cost per kilowatt may be often more than the primary cost charged for purchased power.

It is also true that railroad organizations are not equipped to operate properly and to maintain small power plants. The supervisory forces are necessarily interested in other things than power production, and their experience lies in other directions. There may be, therefore, considerable danger that the local operating forces of the various power plants, left to their own devices, may drift into bad habits, ultimately causing expensive renewals.

Conditions, of course, vary at each location, but in thickly settled territory it is often practicable to purchase power from more than one feeder, in which case the reliability of purchased power usually is entirely satisfactory; perhaps more so than with local production.

Sidney Withington,
Electrical Engineer, N. Y., N. H. & H. R. R.

The Turbine Room at Night

A Model Oil-Burning Railroad Power Plant

M. K. & T. Plant at Parsons, Kan., Shows Monthly Saving of from $5,000 to $9,000

THE Missouri, Kansas & Texas has built and placed in operation a power plant at Parsons, Kan., which is modern in every respect and which contains many features not to be found in the average railroad power plant. The plant provides steam, air and electric power

Exterior View of the Power House

for the railroad terminal and the present cost of generating the steam, electric power and of compressing air as compared with the cost of doing the same in the old plant shows a monthly saving which varies from $5,000 to $9,000.

Electric power is developed by two bleeder type turbine generator sets. A turbine driven rotary air compressor and a synchronous motor driven air compressor make it possible to obtain a good heat balance and corresponding high efficiency for both day and night loads. All water, oil, air, steam and electric power which is used in the plant or which passes through the plant is measured. The metering apparatus used consists essentially of eighteen recording integrating and indicating flowmeters and a number of watthour meters on the switchboards. Exhaust steam is used for heating and for operating the rotary air compressor.

Boiler Room

The boiler room equipment consists principally of five, 516-h.p. Babcock & Wilcox Sterling type, oil fired boilers designed for 200-lb. steam pressure. One hundred deg. of superheat is maintained with Elesco superheaters. At present, under normal conditions, two of the boilers operating at 165 per cent rating are in service at one time.

The boilers have back shot type Peabody burners and draft is provided by a Custodia radial brick stack 200 ft. high and 10 ft. in diameter. Exhaust steam is used to heat the fuel oil and keep it fluid. Oil pressure to the burners is maintained by automatic reciprocating pumps. The feedwater is kept at a temperature of approximately 216 deg. F. by a Cochran feedwater heater with a measuring and wiering device. Water so treated as to practically eliminate scale formation is used as feedwater. It is pumped into the boilers by two Worthington steam driven, 12-in. by 7½-in. by 15-in. duplex pumps. The pumps are controlled by a Copes automatic water regulator.

On each boiler front, where the fireman can see them are indicating gages showing steam pressure, boiler horse-

power and draft. Each boiler is also equipped with individual CO_2 machines and thermo-couple recording and indicating pyrometers of the smoke chart type.

Power Machinery

The machinery in the main turbine room consists of two 1,000-kw. turbine driven generators, one 600 kw. and one 240-kw. motor generator sets, a motor driven air compressor, a turbine driven air compressor, a steam driven air compressor and two turbine driven fire pumps. In addition to the machinery, there is an alternating current switchboard, a direct current switchboard, a flowmeter board and a wall panel on which a number of gages are mounted. This panel contains gages showing feedwater pressure, air pressure, exhaust pressure or vacuum, water pressure, boiler steam pressure, water suction or city water pressure and a clock protected from possible dam-

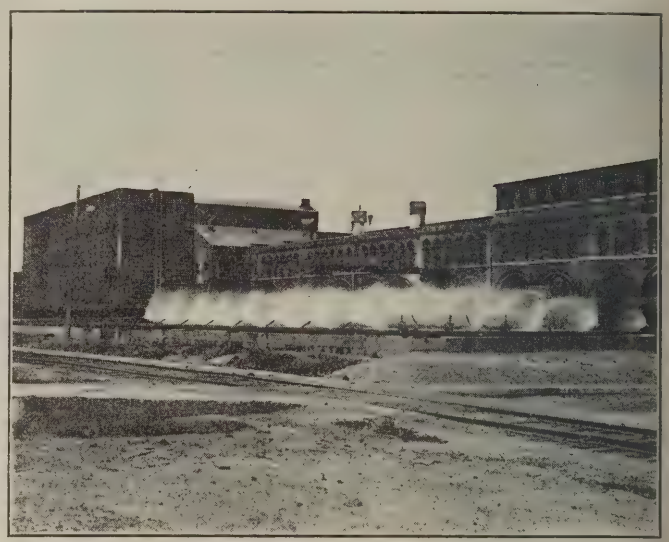
The Five Oil Fired Boilers

age by stray magnetic fields. Two smaller panels mounted on the wall opposite each of the turbo generator sets have gages showing steam pressure, vacuum and speed in r. p. m.

Exhaust steam is used for heating, high pressure steam for blowing engines, compressed air for operating air tools, etc., and electric power is used for driving machines and lighting the back shop, car shop, enginehouse, foundry, reclamation plant, passenger station, general storehouse, fuel department building, ice plant, laboratories, railroad Y. M. C. A. office building, record building, and for all yard lighting and yard and crossing signals.

Turbine Generators

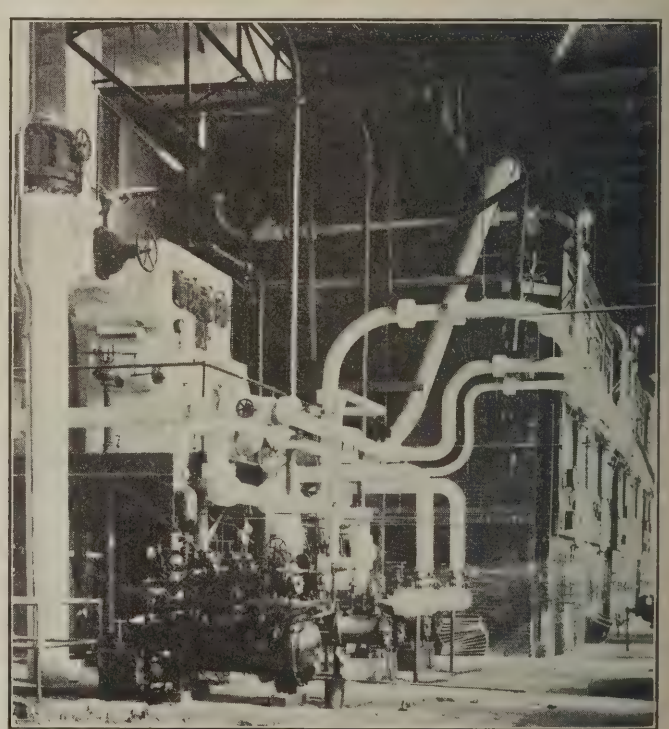
All electric power is developed by two 1,000-kw. Curtis turbine generator sets running at 3,600 r. p. m. The turbines are 3-stage bleeder type turbines designed to operate on steam at 175 lb. pressure and 100 deg. superheat. Each turbine is directly connected to a 1,000-kw. General Electric 60-cycle, 2,300-volt alternating current generator.



The Spray Pond

The exciter which is mounted on the generator shaft consists of a 16-kw., 125-volt direct current generator.

A single Schutte & Koerting jet condenser is used in conjunction with either or both of the turbines. It is unique in that it has no air exhaust pump; the air being carried out of the condenser by ejector action of the cool-



Feedwater Heater, Boiler Feed Pumps and Oil Pumps

ing water. Only one of the turbines is used at a time, but should it be necessary to use both, the condenser can be made to take care of both by changing the size of the jet or spray head. Four Cameron turbine driven volute pumps are available for pumping condenser water. Two

of these are used at a time; one for pumping cold water into the condenser and the other for pumping the condenser exhaust water from the hot well to the spray pond.

Air Compressors and Fire Pumps

The plant is equipped with three air compressors. One of these is an Ingersoll-Rand rotary compressor of 3,600 cu. ft. capacity driven by a mixed pressure steam turbine. The machines run at from 6,000 to 6,600 r. p. m. The turbine operates ordinarily on steam at 5 lb. pressure taken from the bleeder type main turbine at a point between stages, but can when necessary be supplied with high pressure steam. A vacuum of 27 in. mercury is maintained on the compressor turbine by a separate condenser. The compressor delivers air to the air lines at 100 lb. pressure.

The second air compressor is an Ingersoll-Rand two stage class P. R. E. 2 reciprocating air compressor with air cylinders 20½ in. by 24 in. and 33 in. by 24 in. respectively. It is driven by a General Electric type A. T. I. 680-h.p., 164 r. p. m., 2,300-volt synchronous motor.

The third compressor is an Ingersoll-Rand, two-stage, tandem compound steam driven air compressor. This machine operates on steam at boiler pressure and is somewhat smaller in capacity than the motor driven compressor.

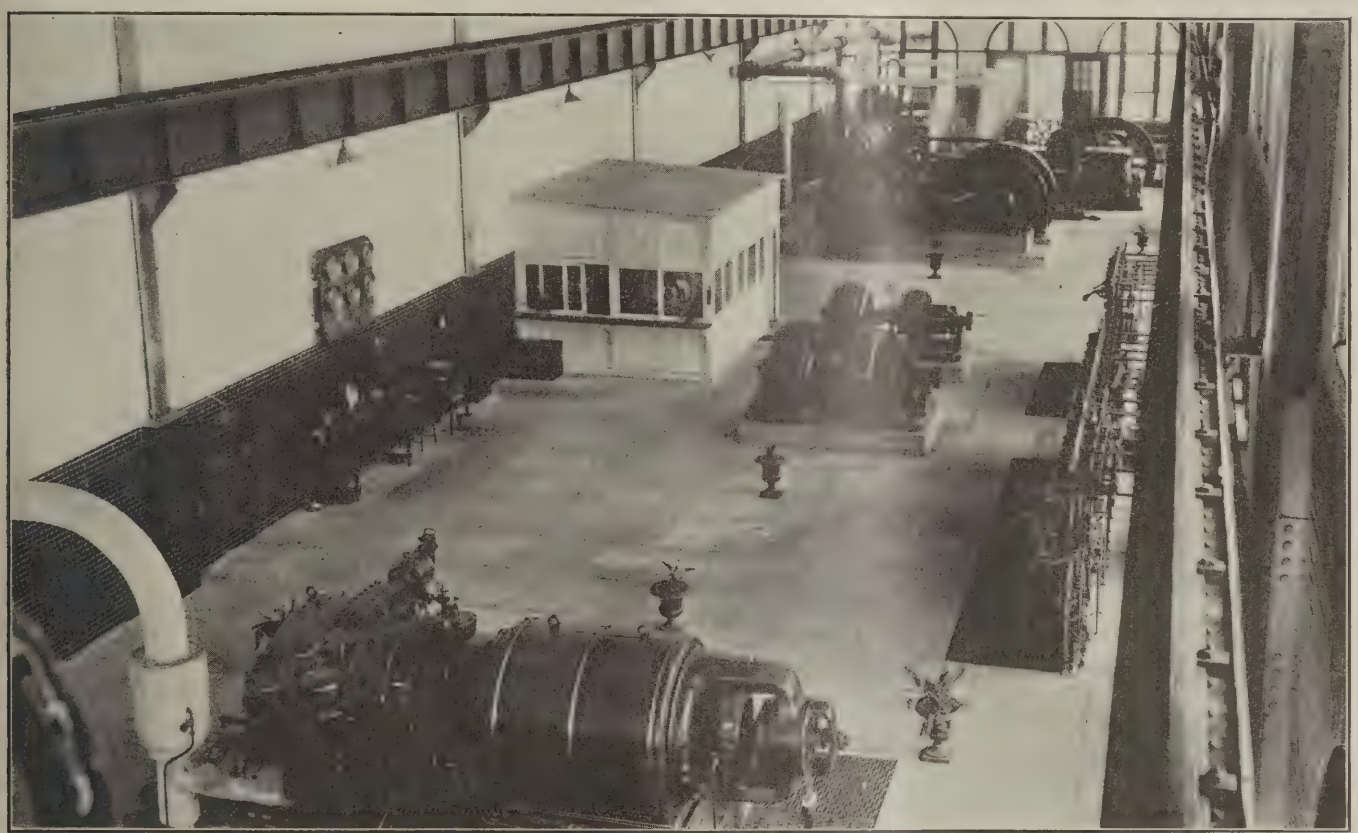
Two fire pumps are installed in the plant. They are Worthington size 6-CL-BS centrifugal pumps each driven by a Curtis 100-h.p. non-condensing steam turbine running at 2,200 r. p. m. on 175 lb. boiler pressure steam. One of these pumps runs constantly holding pressure on the fire line at from 85 to 90 lb. This pressure can be raised when wanted to 120 lb. The turbines which drive the fire pumps are identical and interchangeable with those used to drive the pumps on the main turbine condenser.

Flowmeters

The flowmeter installation is probably the most unusual feature of the plant. It is located in the built-in office in the turbine room and consists of 18 Republic recording and integrating flowmeters and 3 Bristol recording gages.

Five of the flowmeters are connected to the headers of the five boilers. They record the rate at which steam is being delivered by the boiler at any time and also show the total amount of steam delivered by the boiler. The remainder of the flowmeters are used as follows: one on each of the two turbines; one on feed pumps and auxiliaries; one on high pressure steam line to turbine air compressor; one on low pressure line to turbine air compressor; one on water delivery of fire pumps; one on shop high pressure steam line; one on shop low pressure steam line; one on back shop air line; one on yard air line; one on roundhouse and old shop air line; one on roundhouse steam line.

The Bristol gages record temperature of superheated steam, draft and boiler pressure.



Interior of Turbine Room. One of the Two Turbines Is Shown in the Foreground

Motor-Generators

Alternating current is used for lighting and for the operation of the motors in the shops. Crane motors and variable speed motors are operated on direct current and this direct current is developed by two motor generator sets which receive alternating current power from the turbine generators.

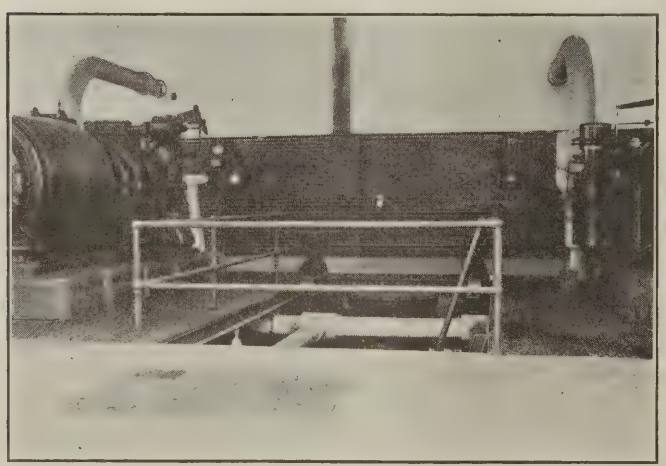
The two sets are not the same size. The larger set consists of a General Electric, type ATI, 2,300-volt, 850-

hp., 900 r.p.m., synchronous motor driving a type M. P. C. 250-volt, 600-kw. direct current generator. The smaller set is similar to the larger one except that the motor is rated at 350 hp. and the generator at 240 kw.

Switchboards

There are two switchboards, one for controlling all alternating current circuits and the other for direct current circuits. At one end of the a. c. switchboard is a bracket panel on which are mounted two a. c. voltmeters, one d. c. voltmeter and a synchronism indicator. By means of plug switches these instruments are made to serve both of the main turbine generators. The switchboard proper consists of 13 panels. From right to left as shown they are used to control circuits as follows: (1) two main generator exciters; (2) No. 1 turbo-generator; (3) No. 2 turbo-generator; (4) voltage regulator (this panel is also fitted with curve drawing instruments showing power factor and kw. output of main generators); (5) 850-hp. motor of No. 1 motor generator set; (6) 350-hp. motor of No. 2 motor generator set; (7) air compressor motor; (8) rivet heater circuit; (9) reclamation plant; (10) passenger and freight depots; (11) old shops; (12) shop lights; (13) yard lights. All panels except No. 4 are equipped with indicating ammeters and all panels except Nos. 1 and 4 have integrating watthour meters. This means that all outgoing power and all generated power is measured. Each circuit is protected by oil switches with automatic release and inverse time limit overload relays. The yard lighting panel controls the primary of two series lighting transformers. The two small series lighting panels are located between the two main switchboards.

The direct current switchboard is made up of 8 panels



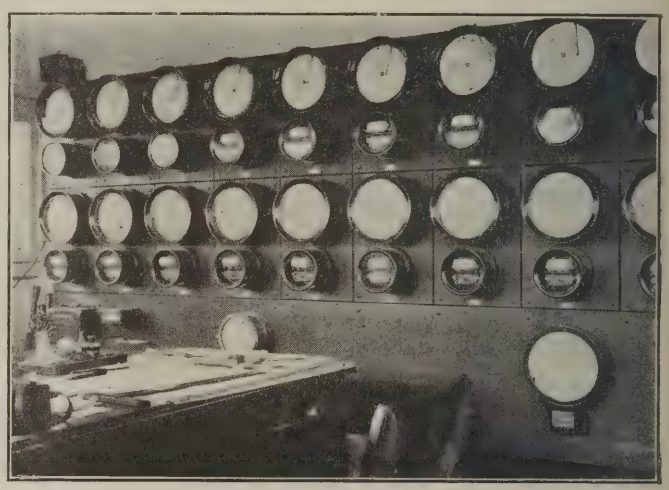
Condenser in Pit Located Between the Two Turbine Generator Sets

controlling circuits as follows: (1) 600-kw. generator of No. 1 motor generator set; (2) 240-kw. generator of No. 2 motor generator set; (3) curve drawing wattmeter and d. c. voltmeter; (4) old shop power; (5) locomotive shop power; (6) blacksmith shop power; (7) cranes; (8) shop office building and truck battery charging set. Both generators are protected by circuit breakers equipped with overload and undervoltage relays. All outgoing circuits are protected by overload circuit breakers and the power in generator circuits and all outging circuits is measured by integrating watthour meters.

Interior Finish and Lighting

The main turbine room, 208 ft. long and 44 ft. wide, presents an unusually attractive appearance. The lower 8 ft. of the inside walls is faced with brown tiled brick. Windows and door frames are painted black and all steelwork battleship gray. The walls and ceilings are white. The floors are concrete painted a blue slate color. All the machinery is dark green, gold trimmed. The entire turbine room is served by a Whiting, 15-ton crane.

The turbine room is lighted at night by 7 Benjamin R. L. M. type reflectors hung from the ceiling above the



The Flowmeter Installation

crane, 7 elliptical or angle reflectors on each side and one on each end wall. Each reflector is fitted with a 300-watt type of C lamp. Two switches control the ceiling lights and four control the lights on the side walls.

Power Factor

Power factor is kept practically at unity throughout the entire 24 hours of the day in spite of the fact that there are a large number of induction motors in the shops which tend to reduce the power factor. During the day there are three synchronous motors in operation, one driving a blower in the shop and one driving a line shaft in the reclamation plant, the third being the motor on the larger of the two motor generator sets in the power house. These motors are over-excited and effectually hold the power factor close to unity. At night the synchronous motors in the shop and reclamation plants are shut down while the smaller motor generator set is big enough to carry the d. c. load and is therefore used in the place of the larger one. This reduction of synchronous motors in service is offset, however, by substituting the synchronous motor driven air compressor for the turbine driven compressor.

Heat Balance

During the daytime hours of operation steam is taken from the boilers at 200 lb. pressure and 100 deg. superheat to one of the main turbines which is a bleeder or extractor type turbine. Enough steam is taken from a point between the first and second stage of the turbine at a pressure of 5 lb. to operate the turbine driving the rotary air compressor, to supply steam for the heating system and to heat feedwater.

The electrical load on the turbine driven generator is

sufficiently high during the day to warrant good efficiency and there is enough low pressure steam for the rotary compressor. The turbine efficiency in kilowatt hours per pound of steam is of course not as high as it might be as low pressure steam is extracted ahead of the second stage. Overall efficiency, however, is very good. The turbine uses 21 lb. of steam per kw. hr. while extracting and about 15 lb. when not extracting.

During the night the shop a. c. load is light and the small motor generator set is large enough to provide for the d. c. power requirements. Such a reduction of load on the main turbine generator would reduce its efficiency but by substituting the motor driven air compressor for

Alternating Current Switchboard on the Right and Direct Current Switchboard on the Left

the rotary compressor, the load on the main generator is kept up and efficient operation maintained.

Savings

The boilers in the plant evaporate 14.21 lb. of water per pound of oil and cost of generating electric power is estimated at less than one cent per kilowatt hour. Power demands on the plant have been approximately constant but fuel costs have been reduced more than $5,000 per month.

The cost of developing the necessary power with the old plant which was displaced by the new one was about $13,000 per month. In January, 1923, it was $13,048.25; in February it was $14,234.82 and in March it was $15,792.17. During the corresponding months of 1924, the cost of power as developed by the new plant was $8,190.60, $6,219.00 and $6,575.90 respectively. Maintenance costs have been similarly reduced.

More efficient machinery is in part responsible for the savings effected. Power was generated in the old plant with non-condensing, reciprocating steam engines direct connected to electric generators.

Another important factor in effecting savings was the introduction of proper specifications and methods of testing fuel oil. Fuel oil having a specific gravity of 24.5 is insisted on and the oil is tested periodically to see that the quality is uniform and that it does not contain water or free carbon. The average cost of oil is 91 cents per barrel.

Labor costs have also been reduced as the old plant required four more men than are needed in the new plant. At present the total force for the three shifts is 16 men.

The flowmeters have disclosed wastes, particularly in the air lines. They have also shown that certain departments were not charged correctly for air, water and steam. The shop was previously charged with 59 per cent of the air compressing costs while 41 per cent was charged to the roundhouse and yards. The flowmeters disclosed the fact that the actual conditions were reversed; the shop using 39 per cent of the air.

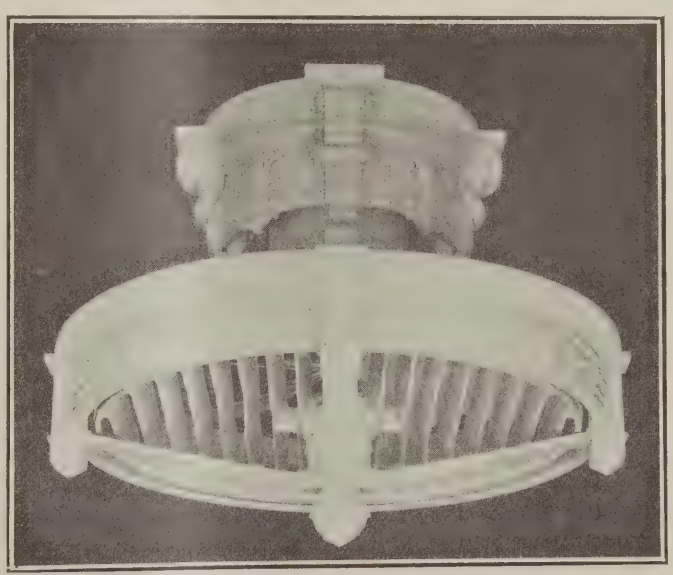
The amount of oil used for lubrication has been reduced from 29 barrels to 3 barrels per month. For the most part this reduction is effected by machinery having bearings which use the oil efficiently and do not waste it. A part of it is accomplished by a water filter. After the oil in the turbine bearings has been used a certain length of time it is removed and run through the filter. The filtered oil makes a high grade lubricant for lathes, motors, line shafts, etc., in the shop and it is used for this purpose, the power plant being given credit for oil used in this way.

Additional fuel and labor savings will be effected as soon as three 250-hp. boilers now operating in the roundhouse can be shut down and steam piped from the new plant. A fuel saving of approximately $4,000 per month and a saving in operating costs of $500 per month will be made by this change.

The plant was designed by M. C. M. Hatch, general mechanical superintendent and C. C. Chase, power plant superintendent, and was installed by Mr. Chase with railroad forces.

An Ornamental Electric Fan

An attractive ceiling fan has been developed by the Safety Car Heating & Lighting Company, New Haven, Conn. In addition to having a pleasing appearance, it



A Ceiling Fan of Exceptionally Pleasing Appearance

indicates possibilities in the way of ornamentation. The particular type has several improvements, among which is the omission of the belt drive between the air propeller and the air deflector.

Induction Motor Faults and Repairs

By Alfred C. Turtle
Shop Electrical Engineer, Canadian National Rys.

WHERE many types and makes of motors are handled, many peculiarities of failure will be observed in the different makes; for instance one series of a certain motor always gave trouble at various periods of service due to *frame distortions.* It was evident that in this class of motor that the castings were not seasoned or heat treated in order to remove stresses which are always present in castings not so treated, therefore in the larger motors, uneven air gap—loosening up of laminations and troublesome fitting of new bearings was a general rule. This meant that after a period of four years' service or so that each unit had its end bells re-bored and the periphery of the end bell turned up to make a centered fit on the frame. The frame received new retaining rings which were put in place with the laminations under pressure thus ensuring non-movement of the lamination. After the frames were thus treated they were set up, centered and bored to fit the end bells. These operations of course were only effected when rewinds were necessary or when the motor was no longer in condition to operate.

Another type became famous due to its rotor bars loosening up on the end rings and in some cases where its application had been made on machines having large inertia, viz., punching shears and such loads where the necessity of keeping the motor size to a minimum on account of the fact that such machine required a little power to operate when running but considerable power to start and get under way; it was found necessary to remove and substitute motors of suitable characteristics. Where only the motor squirrel cage winding heated up and the stator winding remained comparatively cool it was possible to mitigate trouble by interchanging rotors suitable for this duty by arrangement with the original manufacturers.

In other cases brazing of the bars to the end rings was found to be all that was necessary, while in cases where secondary resistance was too low, it was found that a small cut taken off each bar at the points nearest the end ring where maximum cooling effect obtained, would sufficiently increase the rotor resistance to produce the required characteristics. Certain momentum machines actually required the substitution of variable speed induction motors for straight squirrel cage type motors. This was because the length of time required for bringing the machines up to speed was so long that the secondary windings of available motors overheated and eventually failed at the connections between bars and end rings or in some cases heating occurred at too fast a rate for safe operation at both stator and rotor.

Several instances occurred where the eventual result of service, mechanical makeup of the rotor, etc., caused the laminations of the rotor to a certain extent to ease up and give sufficiently to reduce the air gap clearance to an unworkable limit. After a thorough tightening up of the wedges a small cut may be taken with a very sharp broad nosed tool on the lathe on the circumference of the laminations. A cutting speed of approximately 90 feet per minute is used and the laminations are reduced 10 to 12 thousandths of an inch in diameter according to the requirements of each particular unit. In this way a sound and practical unit could be made out of what had otherwise been an outfit which would break down at regular and frequent periods.

It was found that to ensure reasonable service on the average unit that air gap clearance should not be less than 0.030 to 0.045 inch on motors, from 10 h.p. up to 75 h.p. sizes, although for certain classes of service such as motor generator sets, where the effect of beltpull or gear drive would be absent, these air gaps could be allowed to go below this figure. Good judgement should be used in such cases and conservative action should rule, otherwise the characteristics of a motor may be greatly changed so that excessive heating and reduced capacity may result.

A safe formula to use when checking the following is quoted by A. Gray in his electrical machine design referring to induction motors as follows:—in which it will be noted that air gap clearance for good service is dependent upon, the rotor speed, axial length of laminations, and retaining rings, and lastly the rotor diameter.

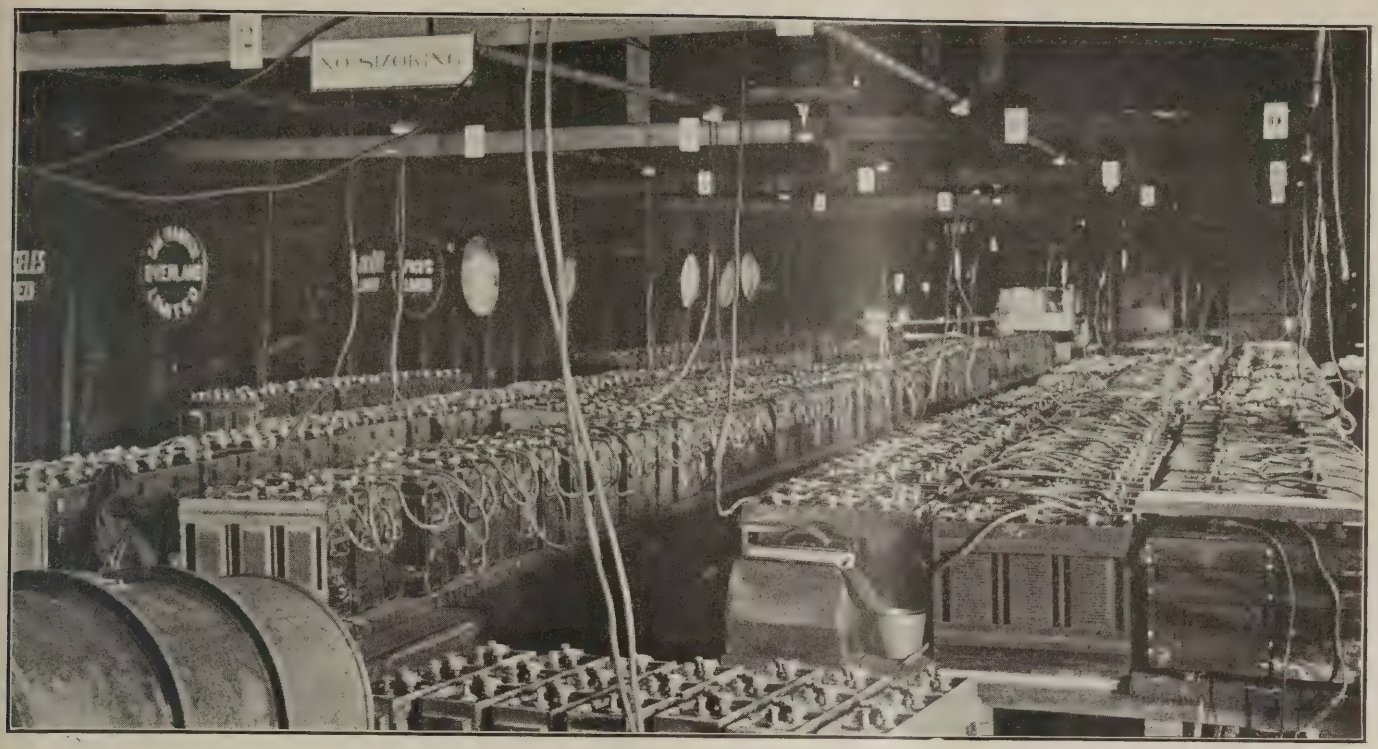
Air gap clearance should equal
.005 plus .00035 Da plus .001Lg plus .003 V
in which
Da equals internal diameter of stator.
Lg equals the gross iron in the frame length in inches at length of laminations and retaining rings.
V equals the peripheral velocity of the rotor in 1000s of feet per minute;
or radius of rotor in feet multiplied by 3.1416, divided into R.P.M. and by 1000.

Where individual induction motors were geared direct to machine tools peculiar trouble was experienced due to breakdown of coils to ground at the top of the laminated teeth of stator and also apparently internal shorting of coils.

A closer investigation revealed the fact that this occurred regularly on machines on which cast iron was machined and while the cuttings were scrupulously kept away from the motors the fine graphitic iron dust was able to percolate around and into the motor, in time causing the breakdowns as outlined.

Suitable screens in some cases, a change of locations of motors in others, and sometimes where no other recourse could be had, a complete closing in of motor had to be resorted to. This last was done very reluctantly as it must be remembered that the total enclosing of a motor will materially decrease the life of its insulation. Just the bare fact of enclosing a motor will increase its temperature anywhere from 2.2 to 3 times its normal running temperature even when the covering is wholly metal, and if the room temperature is nominally around 70 deg. Fahrenheit it is very apparent that a cotton carbonizing temperature would tend to prevail and thereby soon ruin the motor winding unless the covering is such as to radiate heat as fast as it absorbs it.

Therefore when covering motors wholly, it is very important that thin sheet metal of good radiating property be used. For instance tin plate of No. 20 gage painted dull black on the inside and having its exterior surface left in its original bright surface, would make an ideal covering for motors subject to fine dust of a metallic nature or in any service where local conditions required the motor to be covered in.



Edison Batteries "On Charge" in the Union Pacific Battery House at Council Bluffs, Iowa

Maintaining Edison Car Lighting Batteries

Methods Used on Union Pacific Are Highly Effective and Labor Required Is Reduced to a Minimum

THE Union Pacific, one of the largest users of Edison storage batteries for car lighting purposes, has developed unique and effective means for taking care of these batteries at Council Bluffs, Iowa. The work

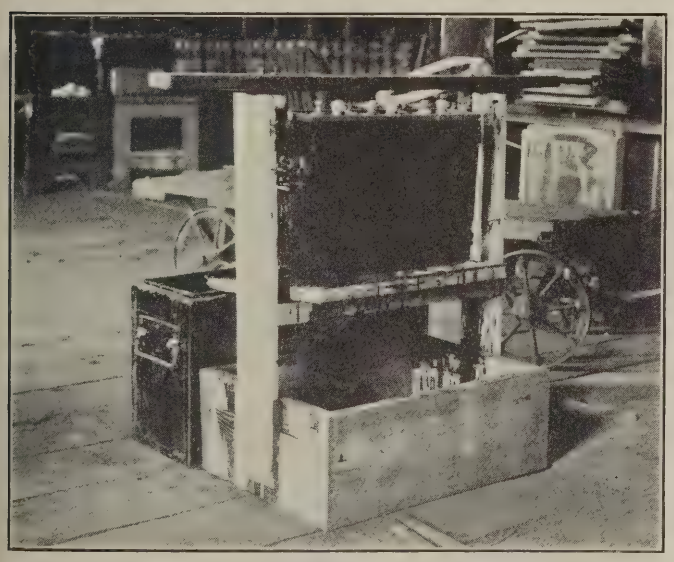


Fig. 1—Rear View of Painting Equipment Showing Construction of Stand

done consists essentially of keeping the containers painted, renewing the electrolyte when that is needed and welding an occasional cracked container.

Painting

Battery tanks and crates, or trays, as they are called, are painted approximately every three months, depending upon how and where the battery is used and upon the location of the car which contains the battery at the time when the battery is scheduled for repainting.

The painting process is an extremely simple one as performed at the Union Pacific shop. The greater part of it is done by dipping and the apparatus used for this purpose is shown in Figs. 1 and 2. It consists essentially of a stand, a draining trough or tray, a tank and a lifting device.

The stand is shown best in Fig. 1. The rectangular base is made of 1½ in. lumber and is 32 in. long, 20 in. wide and 12 in. high. Nailed to the ends of this base are two vertical pieces 6 in. by 1 in. in section 48 in. high. The upper edge of the cross strip which holds one end of the tray is 22 in. above the floor.

The tank is made of 1-in. lumber lined with galvanized iron. The inside dimensions of the tank are 10 in. by 32 in. by 20 in. high. It is kept filled with paint up to a level about 6 in. from the top.

The draining trough consists of a galvanized iron tray 18 in. by 28 in. in size with three edges 1 in. high turned up and the fourth turned down over the edge of the tank. One edge of the trough rests on the tank and the other on the cross strip between the two vertical members of the stand.

The lifting device is shown lying across the top of the

two uprights with a battery crate containing three cells suspended from it. It consists of a straight piece of wood about 2 in. by 3 in. in section, 4½ ft. long. Bolted to this piece are two Z-shaped pieces of ¼ in. by 1 in. strap iron so spaced that they will fit under the cleats on the ends of the battery crate.

When a battery is brought in to be painted the tanks and crates are first cleaned with a steam jet. After it is dry two men then pick up the crate and batteries with the lifter and dip it down into the paint tank so that the paint in the tank comes up to within half an inch of the upper edge of the batteries. The crate is then lifted out of the tank to the position shown in Figs. 1 and 2, where it is allowed to drain while the upper edge not coated by the dipping process is touched up with a brush. The battery shown in the illustration is a 3-cell, type A-8-H, 300 ampere-hour car lighting battery. The size of dipping tank used, however, is suitable for painting any size or type of Edison car lighting battery.

The final painting operation consists of using a brush to coat the tops of the batteries with varnish or rosin vaseline. The object of the painting is to prevent damage to the cans from rust.

Renewing Battery Solution

At intervals of three to five years it is necessary to renew the electrolyte in the batteries. This means replacing the old electrolyte with new and removing sediment from the bottom of the battery cans or containers. The best method for removing the sediment is to lay a battery half filled with solution on its side and shake it back and forth until the sediment is washed out.

An ingenious mechanical device, shown in Fig. 3, has been made for this purpose, which will shake three three-cell trays of battery at a time. The device is driven by a 3 h.p., 110-volt motor running at 1,800 r. p. m. This motor was used because it was available. A much smaller motor would do, as the load on the motor when in operation is only 5 amperes or 550 watts. The motor is fitted with a 3-in. pulley belted to a 30-in. pulley. On the shaft with the 30-in. pulley is an 8-in. pulley belted to a 24-in. pulley. On the shaft with the 24-in. pulley is a 4-in. crank. The speed reduction is 30 to 1 so the speed of the crank is 60 r. p. m. A piece of ½-in. pipe 6 ft. 6 in. long connects the end of the crank to the shaking table. A pipe T and a rod which fits the inside of the T form the bearings at each end of the pipe connecting rod. Damaged axle generator bearings are used as bearings on the pulley shafts which run at higher speeds. The outer races of these bearings are clamped between two wooden blocks with ½-inch bolts and the same bolts hold the blocks and bearings secure on the framework of the machine.

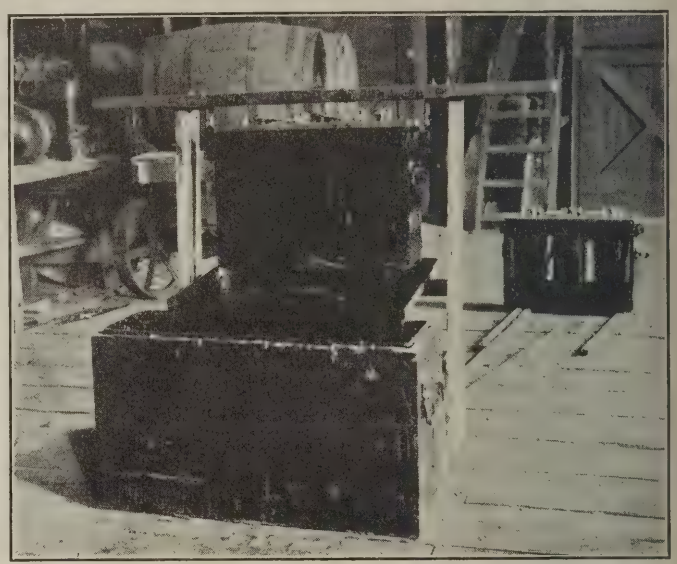


Fig. 2—Front View of Painting Equipment Showing Dipping Tank and Draining Trough

The shaking table or cradle is shown in Fig. 4 and at the left back of the washing table in Fig. 3. The shaking table is 2 ft. 3 in. wide by 5 ft. 10 in. long and is fitted with cleats to keep the batteries from sliding off the table. It is suspended by four rocker arms from four uprights which in turn are bolted securely to a rectangular base made of 2 in. by 12 in. planks. The rocker arms are 20 in. long between centers and ½-in. pipe is used as the bearing and support at each end of the four rocker arms.

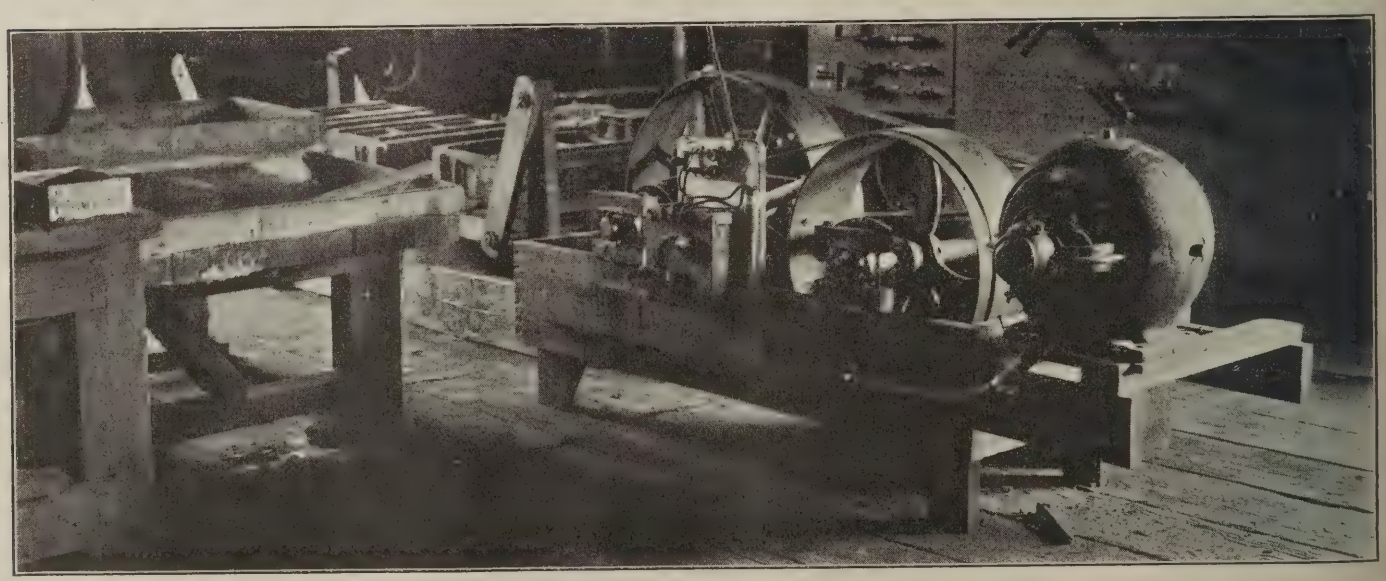


Fig. 3—Shaking Machine for Washing Sediment Out of Batteries

When it becomes necessary to renew the electrolyte in a battery, the battery is brought into the shop, and half

of the electrolyte is poured out of each cell and saved.

A tight rubber plug is fitted into the filler opening and the battery crates, three at a time, are layed on their sides on the shaker table. The motor is then started and the batteries shaken for from 10 to 15 minutes. With a little experience, it is possible to tell whether or not the sediment is all washed free by rapping on the bottom of the tanks. A dull sound indicates the presence of sediment while a sharp click or ring shows that the sediment has

Fig. 4—Cradle of Shaking Machine with Three Batteries in Place

been washed off the bottom of the can into the solution.

After the sediment has been washed free, the dirty solution is poured out and the half that was poured out before the shaking process was started is poured back. The shaking process is then repeated for 2 or 3 minutes and the rinsing solution poured out and thrown away. In rare cases when the rinsing solution does not come out clear, the rinsing operation is repeated.

After the rinsing operation is completed, the battery is filled with standard renewal solution and the outside of the cans and crates or trays cleaned and painted. The battery is then given a 12-hour charge at the normal charging rate and put back into service.

New Tunnels in Northern Italy

Welding Practice on the Santa Fe*

H. A. Patterson
Welding Foreman, A. T. & S. F. Ry.

EVERY standard welding operation performed in our shops is covered by specifications as contained in our welding folio. If we apply a new crown sheet to a firebox our folio shows us the number of inches our weld must be from the highest point of the sheet. It tells us the electrode best suited for the job and recommends an approximate current value for this class of work.

While circumstances somewhat alter cases, this folio is a constant guide and advisor in all our work. If some shop foreman requests a flat spot on a driving tire built up and our folio contains a paragraph forbidding this operation, we can refuse and have something to back us up. In other words, it explains to us that which our officials and engineers want, and thereby we strive for results according to their plans and desires and our own mechanical ability.

All of our welders are compelled to make monthly test plates. These plates are tested and analyzed and the welder informed of his progress.

I have recently read with much interest in the Journal of this Society and other publications, some wonderful and speedy operations that certain men claim they have accomplished in arc welding with a large electrode and a high current value. Now, on my first introduction into the great field of electric arc welding several years ago, we used for filler rods strips of sheared boiler plate, ⅜-in. round wrought iron rolled steel bars used in automatic screw and other machines—in fact, mostly anything we could salvage from the scrap pile or otherwise. Later developments led us to settle on a ¼-in. American iron rod manufactured primarily for the oxy-acetylene flame, and I can vividly remember using a current value as high as 350 amp.—a soft iron welding rod 36 in. in length; and the operator held the electrode holder—a big, cumbersome tool, in both hands, as if it might be some tool of torture. Later developments reduced the diameter of our rod to 3/16 in., and today our welding folio shows no specifications calling for a welding rod larger than 5/32 in. or a current value of much over 150 amp.; and we are doing pressure welding on locomotive boilers with a low current value, ⅛-in. and 5/32-in. electrodes, maintaining our high standard as to quality of weld and character of workmanship, which would be impossible to accomplish with 3/16-in. and ¼-in. electrodes. In this connection let me emphasize that in the railroad shops today we are just as keen on shop output and production costs as those who operate contract shops, and we must produce results that will satisfy our own and Government inspectors and stand up under hard and sometimes unfair usage and to do all this it must be right.

As most of you no doubt know it has been for years our standard practice to weld all our boiler flues to tube sheet on firebox end. This is accomplished by expanding and beading the flue in the usual manner; then welding flue bead tight to the sheet by depositing a layer of metal around flue, equally distributed between the flue bead and sheet. While this operation has lengthened the time between flue removals the body of the flues has been found

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to contain a greater amount of pits. This can possibly be accounted for because on certain districts where before welding we got from 8 to 18 months' service out of a set of flues, they now go from 36 to 48 months before resetting is necessary, and while this pitting is easily handled by building up the pitted spots, I believe this is an interesting by-product of welding development.

In our shop considerable locomotive frame welding is done. This operation, when properly performed, is a big money saver for all concerned. We have one class of engine that is a chronic frame breaker in a certain section, and this break always occurs at a point where it is impossible to reinforce if welded. Now, if due to some peculiar strain or some unknown condition that causes fatigue of the metal at this given point, it is only with difficulty that the parent metal is able to withstand this strain, it should be impossible to expect a fusion weld that cannot even so much as be reinforced to hold in this same said section. Now, to overcome this difficulty, we cut out a section of the frame and replace it with a carefully annealed steel patch, bringing our welds back to a point where they can be reinforced, and what our weld lacks in quality we make up in quantity.

Perhaps some of you have been employed in a railroad roundhouse and if so, you can recall the amount of time and energy that was spent in renewing bolts around the machinery on locomotives as the continual strain and stress of the engine would eventually loosen them. When an engine is received in the shop now for general repairs the frame splice bolts, guide yoke knee bolts, frame x tie bolts, tail piece, chafing iron and many others are removed, the holes carefully reamed, new bolts fit to hole and carefully cinched up tight; then, in addition, these are welded securely to engine frames, thereby eliminating considerable running repairs that the mechanic of yesterday did not consider would ever be accomplished.

To some men not familiar with railroad work, it might be interesting to enumerate a few of the welding and cutting operations applied to one of our locomotives undergoing general repairs:

300 rivet heads burned off.
900 stay bolts burned out.
100 ft. of 3/8-in. boiler sheets burned.
Welding in new crown sheet—total welding feet 24.
Two mud ring corner patches welded—36 in.
Two half side sheets welded—248 in.
Front flue sheet patch welded—48 in.
Back flue sheet patch welded—72 in.
Bottom section of smoke box welded—96 in.
220 flexible staybolt sleeves welded to wrapper sheet.
Two 20-in. patches welded in locomotive frame (4 welds).
200 pitted flues built up.
150 oversize staybolt holes plugged in wrapper sheet.
320 flues welded to tube sheet.
Six D boxes brass fit and saddle seat built up.
Worn valve gear parts built up.
Six brake hangers built up.
Set of spring equalizers built up.
Engine truck rails welded to center casting.
Chafing iron built up.
Frame x welded ties to frames.
Guide yoke knees welded to frames.
Spring pocket built up.
Coupler casting welded.
Coupler yoke built up.
Two truck bolsters and frames welded.
Patch in tank side sheet welded.
Set of rod brasses built up.

Two brasses built on boiler head for water glass fittings and innumerable smaller jobs, such as plugging holes, brazing pipes and cutting different parts to fit.

Another subject that must be seriously considered by all railroads and others doing similar work, unless the welding progress is to be retarded, is that of annealing, and I would like to emphasize that by saying careful annealing. When fusion welding was first adopted it filled such a long-felt need that there was a great sympathetic feeling extended it. However, as it became a standard practice, such as any other shop operation, and failures occurred and research work began it soon was discovered that great structural changes were perceptible in the parent metal when these welding operations were being performed. This finally led to the prohibition of welding operations on certain parts by some railroads, such as pistons, x heads, crank pins, tires and other miscellaneous and heat-treated parts. These structural changes likewise take place on numerous freight car castings and most large railroads are now making provision for annealing furnaces, which, with some modification in the A. R. A. rules covering interchange, will open another big welding field in the reclamation of freight car castings.

In conclusion I wish to state that the great trend of the welding developments today is to speed up the operations. Let us do all we can along this line, but let us not sacrifice quality and character of workmanship for speed.

The Interstate Commerce Commission has denied the petition of the Reading Company that it be exempted from the operation of the automatic train control order and also a petition of the Galveston, Harrisburg & San Antonio for a modification of the order to permit it to make its installation on a portion of a division.

Railway Bridges Near Turin, Italy

New Design of Brookins Train Control

Featuring a Normally Raised Descending Type Shoe and Flexible Brush Contact

THE latest design of the train control system of the Brookins Railway Control Corporation may be said to be neither the ramp nor the induction type. It features a descending type shoe normally riding 3 in. above the top of the running rail. The shoe is pneumatically operated downward, on the transmission of a

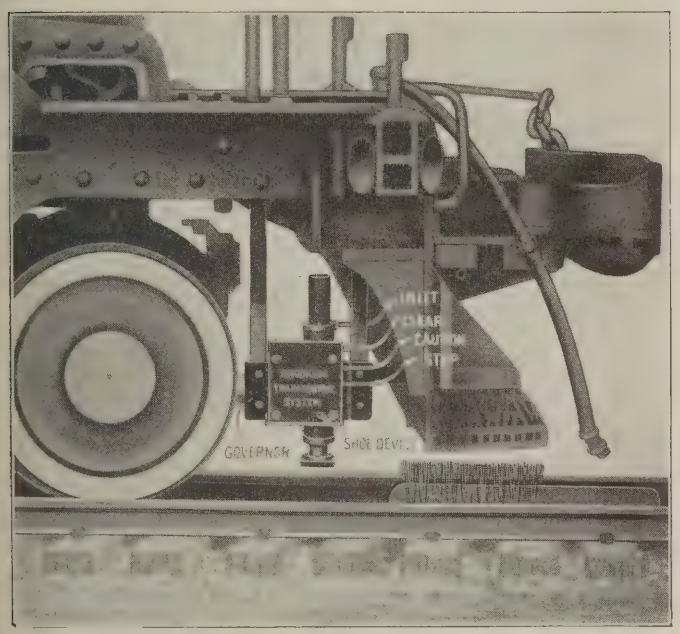


Fig. 1—Assembly of Locomotive and Track Equipment

signal impulse, and after receiving the impulse it is pneumatically restored to its normal position. A special polarized locking magnet is used to control the position of a three-position control piston.

In each block are two brushes, known as "distant" and "home" indication points. They consist of bristles of steel spring wire extending 4½ in. above the top of the running rail and a short rail section 4 ft. long and level with the running rail. A polarized roadside circuit extends to the brush. This circuit is controlled by the condition of the adjacent blocks in advance, and in addition to the regular control relays, a special selector is used to permit a closer spacing of trains and form an element of the speed control feature.

The engine equipment, Fig. 1, consists of a pneumatically operated automatic brake valve, governor and a three-position control device. The brake valve provides for a two stage brake application under "stop" conditions. The governor is normally inoperative and is automatically thrown into service under stop conditions, being used for low speed movements only. It has a drive wheel which is normally inoperative but when a "stop" signal is received the drive wheel will be moved by air pressure against the pony truck wheel of the locomotive, which immediately puts the governor in operation.

Operation of Control Device

The upper end of the control device is formed into a chamber 3 (see Fig. 3), which is connected directly to the main reservoir. It has mounted therein a movable piston 6 and adjacent to chamber 3 is a chamber 4 of a larger diameter than chamber 3. It has movably therein a mounted control piston 5. A valve 15 controls communication between chambers 3 and 4, and it is normally seated on seat 13. When operated its movement is upward into the hollow receptacle of piston rod 7.

The pressure in chamber 3 acting on the under surface of piston 6 will normally hold piston 6, piston rod 7, piston 5, arm 8, shoe 21 and their associated parts in their raised or normal position. In this position the arm 8 will hold the locking magnet and pawls in their neutral or inoperative position (see Fig. 4).

A neutral armature controlled by the electro-magnet is formed into a lock which will lock the polarized armature in neutral position until the electro-magnet is ener-

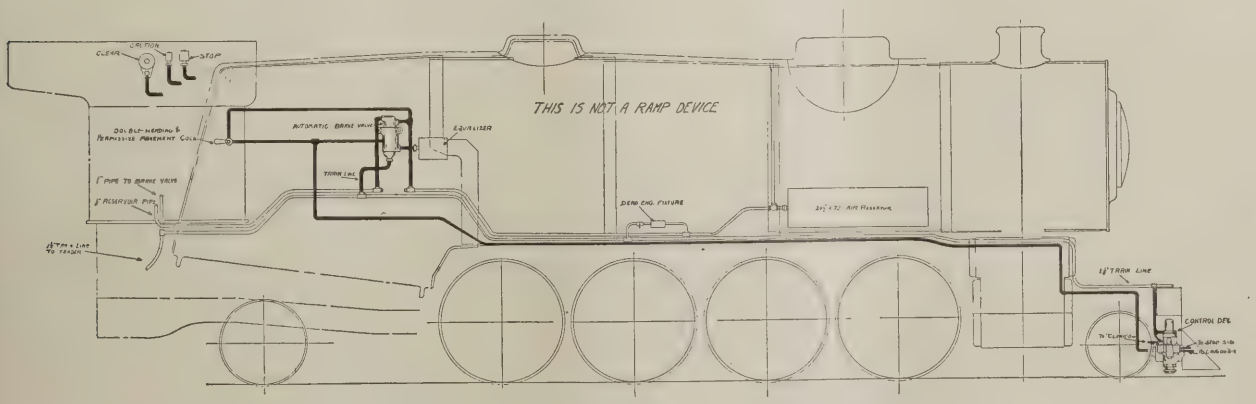


Fig. 2—Relative Position of Locomotive Devices and Pipe Connection. There Is Only One Locomotive Circuit Which Passes Through the Locking Coil

gized. The control arm 8 has recesses 9A and 10A adapted to be engaged by their respective pawls when the polarized armature of the locking arm is rotated in a clock-wise or counter clock-wise direction.

The control device is equipped with a selective valve

to control communication between the train line and the governor. It is arranged to be opened by air from chamber 4, when a "stop" condition exists, and is equipped with a by-pass which allows equalization of pressures on both faces of the piston so that the valve will remain open, as long as the "stop" condition exists. When a "clear" or "caution" indication is transmitted to the train, an exhaust port 35 is arranged to exhaust the air from the underside of the piston which will seat the valve, thereby cutting off communication between the train line and governor.

Operation in Connection with Track Element

When the shoe engages a track brush the brush should afford sufficient mechanical power to lift the shoe slightly, which will unseat the valve 15, admitting air into chamber 4. The air passing into chamber 4, will exert its force on the upper face of piston 5. This piston having a greater area than piston 6, it will move downward, moving piston 6 and arm 8 with it. After a determined movement the shoe 21 will also be forced down. The above operation occurs at every signal point regardless of the indication received.

When a "clear" condition is existing a current of positive polarity will pass from the roadside battery through the contact brush, shoe, coils of electro-magnet on engine, track rail, and return. This will rotate the rocker arm 12 in a clock-wise direction and pawl 9 will be drawn into recess 9A of arm 8 to arrest the downward movement of piston 5, in the position illustrated in Fig. 5. The "clear" port has been uncovered, supplying air to sound the "clear" signal gong in the cab. As soon as the shoe 21 clears the brush the shoe will drop by gravity to seat the valve 15 and open exhaust port 19, releasing the air from chamber 4. The pressure under piston 6 will then return piston 5, shoe 21 and associated parts to their normal or raised position.

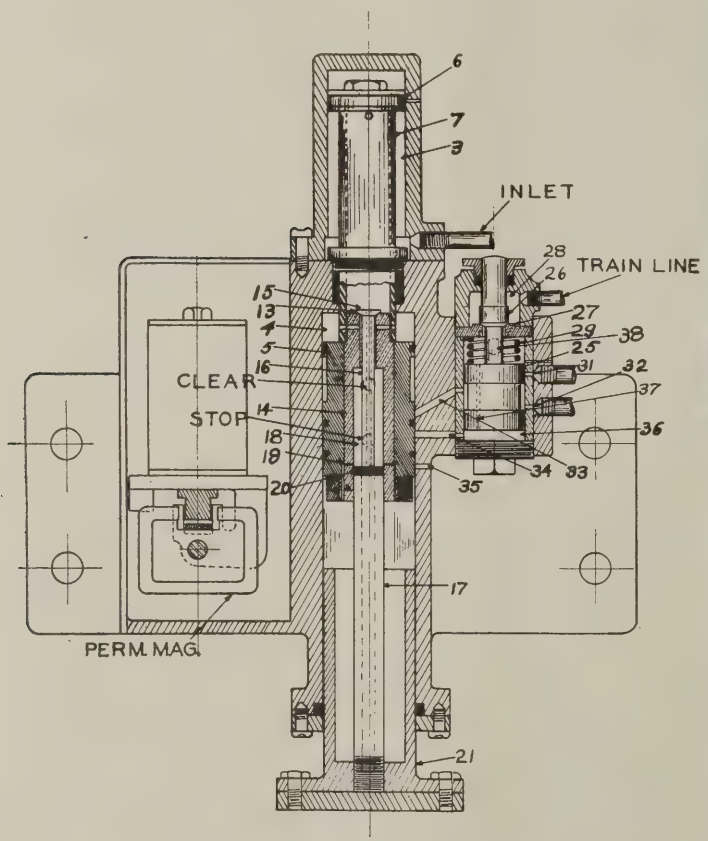


Fig. 3—Shoe Device With Parts in Normal Position

When a "caution" indication is transmitted from the roadside to the locomotive the current through the contact brush will be of opposite polarity from that of a "clear" signal and the locking magnet will rotate in a counter clock-wise direction, throwing into operation the pawl 10, which will arrest piston 5 and locking arm 8 in the position illustrated in Fig. 6. In this position the shoe 21 will ride along the track contact to hold the valve 15 unseated and the "caution" signal will be sounded in the cab. As soon as the shoe rides off the rail the valve 15 will be seated, the "caution" signal silenced, and the piston 6 will return the movable parts to their raised or normal position, as described before.

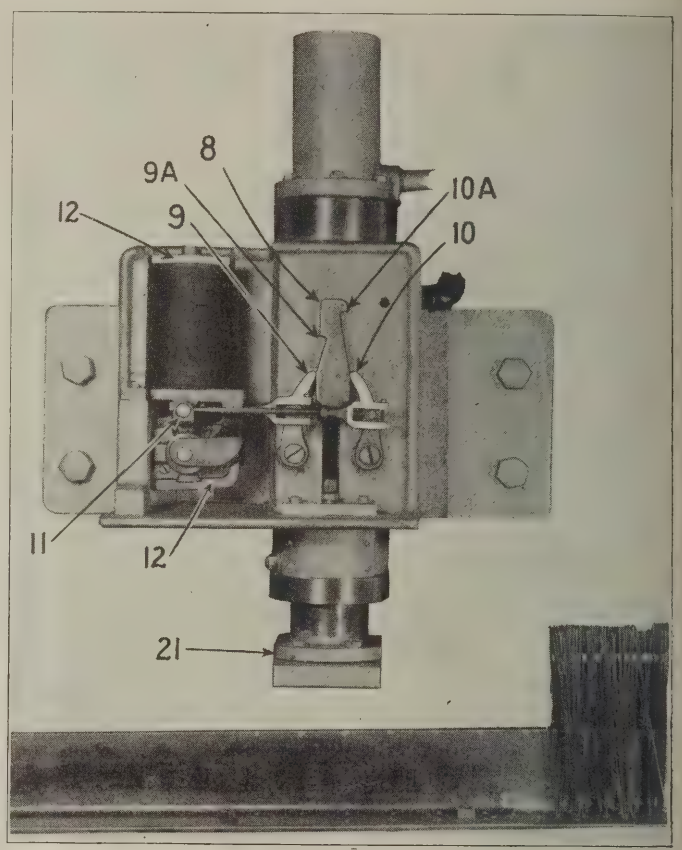


Fig. 4—Shoe Device With Cover Removed, Locking Arms and Latches in Normal Position

When a "stop" condition is existing the current from the roadside battery is cut off from the track brush. The valve 15 will be unseated as the shoe engages the track brush, and piston 5 will begin to move downward as before recited. There being no current at this time the pawls 9 and 10 will remain in their inoperative or neutral position, allowing the piston 5 to move to "stop" position (see Fig. 7).

With the piston 5 in the "stop" position, air through chamber 4 will flow into chamber 36 and unseat the valve 26, which will admit air from the train line into the governor control line. The by-pass 37 will allow air to remain chamber 36 after the piston 5 returns to its normal position. Further movement will be made under "stop" conditions until a "clear" or "caution" signal can be made.

Automatic Brake-Valve Operation

When the control piston is in "stop" position it uncovers the port leading to the automatic brake-valve. The

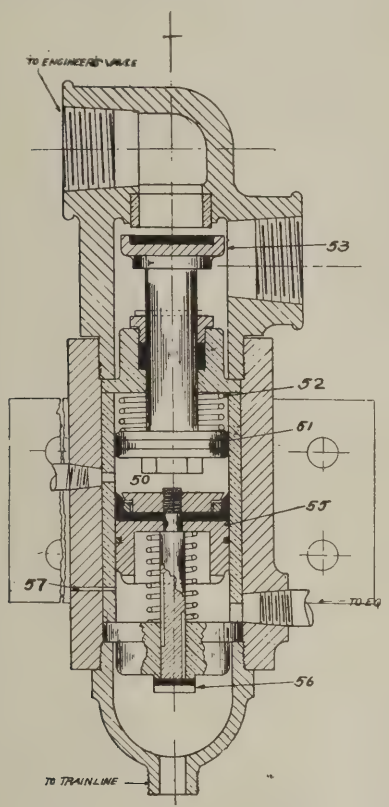


Fig. 8—Interior of Automatic Brake Valve

air passing through this port into chamber 50 (see Fig. 8) will act on piston 51 to overcome the resistance of spring 52, to seat valve 53, thereby cutting off communication between the main reservoir and the train line. At the same time the air in chamber 50 will force piston 55 downward. This piston will cover the port 57 and unseat valve 56, admitting air from the train line to the equalization tank. The air flowing into the equalization tank and governor connections will form the preliminary stage of reduction, which will range from 5 to 10 lb. A heavier reduction will take place as soon as the control piston of the shoe device is returned to its normal position, which will continue until a reduction of about 25 or 30 lb. has been effected, at which time the parts of the application valve will be restored to their normal position. The brakes can then be released by the engineer in the regular manner.

The engineer can forestall the operation of the device when approaching a "stop" indication point by reducing the speed and manipulating the permissive cock, and there will be no brake application as long as the speed of the train remains below a predetermined rate. Medium speed control is provided by a time and space interval method, and low speed by a governor. "Stop" conditions can be avoided until the train in advance comes to a stop, provided the engineer slows down on receiving the "caution" indications. The speed of the train will determine the amount of brake pipe reduction, in addition to the air exhausting through the application valve. There will be an exhaust through the governor until the speed has been reduced to a determined low speed rate.

When a block is occupied the "home" brush will register "stop" and the "distant" brush will register "caution." When approaching a danger zone a "caution" indication is sounded at the "distant" brush. In order to forestall a condition requiring a brake application the speed of the approaching train must be reduced to allow the preceding

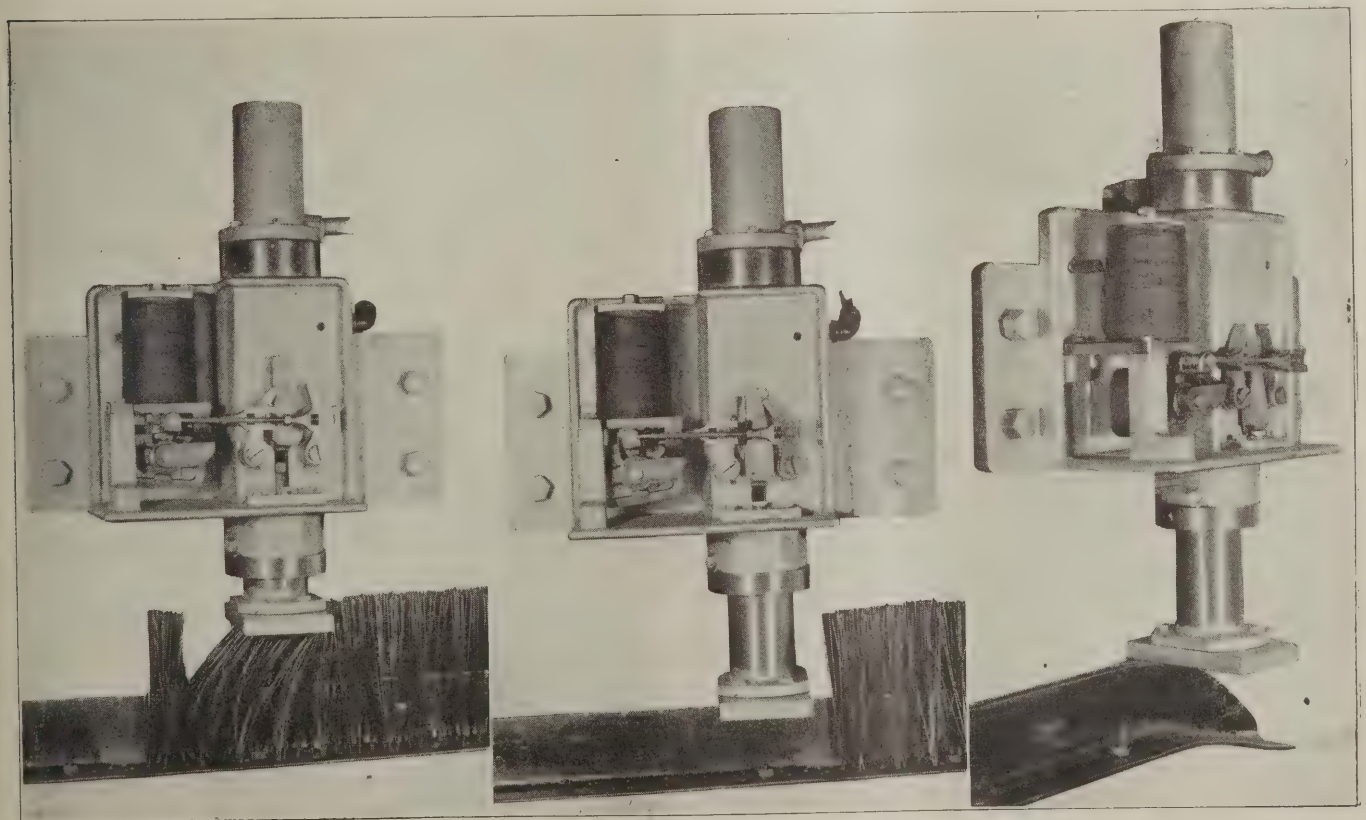


Fig. 5—Receiving a Clear Impulse, Clear Latch in Its Notch

Fig. 6—Receiving Caution Impulse Right Hand Latch Operative

Fig. 7—Receiving Stop Impulse Latches Inoperative

train time to clear the block in which it is moving before the approaching train reaches the home brush of that block. This is determined by the time required for the preceding train, which caused the caution condition to exist, to clear the block in which it is moving, which is inversely in proportion to its speed, the length of the block, and its position in the block at the time the caution condition was transmitted to the approaching train.

Neon Gas for Electrical Use

In 1894 it was noticed by Lord Rayleigh that the density of nitrogen gas derived from the air was consistently slightly higher than that made by chemical means. This observation led to the discovery of argon which constitutes 1.3 per cent by weight (0.933 per cent by volume) of the atmosphere. Since 1914, argon has been manufactured from air for use as an inert gas in incandescent electric light bulbs and for some years now it has largely replaced nitrogen for this use.

After the discovery of argon, the crude gaseous residues left from extraction of nitrogen, oxygen and argon from the air were carefully collected and examined spectroscopically for the presence of other elements. Four were disclosed: Helium (now quite well known as being the balloon gas par excellence), neon, krypton and xenon. These all occur in air in such small amounts that they would be obtainable only at very great expense as scientific curiosities if it were not for the air liquefaction plants now operating in all the large industrial centers. At the present moment argon is the only one that can be called a commercial success. The helium used in balloons, is extracted from certain natural gases, some running as high as 2.5 per cent helium, although the average is considerably lower—whereas helium occurs in air only as one part in 250,000 by volume. Both the argon and the helium depend upon their inertness—what we might call chemical unfriendliness—for their industrial value. So far no application has been found for krypton nor xenon, which both occur in most infinitesimal quantities—many times less than helium.

Neon, discovered in 1898, is more abundant in the air than helium, there being 15 parts of neon in one million parts of air. Like the other gases of the atmosphere neon is colorless, odorless and tasteless; it is very inactive and will neither support combustion (as does oxygen) nor combine with even the most re-active of the other chemical elements or compounds. It is very difficult of liquefaction, a temperature of 246 deg. C. (475 deg. F) being necessary; purification must be carried out at liquid air temperature in special and expensive apparatus, absolute purity being quite difficult of attainment.

Electrically, neon is most unusual. It is exceedingly sensitive to electrical discharges; a tube containing a bit of mercury sealed in with pure neon when shaken will cause the neon to glow. The gas has an electrical conductivity seventy-five times as great as air. When in rarefied condition, pure and dry, the passage of a high tension electric current causes it to glow with a very beautiful and noticeable orange red light. Numerous limited uses of these properties have been tried out so far. There is no doubt that neon has a commercial future when its proper applications are developed. Already some strikingly beautiful lighting effects have been produced and though the use of the gas is not widespread, it has met with much favorable comment among advertising and display experts.

For signal purposes there is no doubt that the neon light has unique possibilities when its method of use has been suitably worked out. The neon light is not one that can be overlooked, its color and general characteristics being of a peculiarly distinctive nature. It has high visibility in daylight, and in fog, as well as having special brilliance at night.

In like manner neon is coming into use as the current carrying agent in safety devices designed to protect electrical instruments and buildings from high voltages. These devices because of the peculiarities of neon will allow hardly any current to pass below what is known as their break-down voltages. In fact, below this point the current flowing through the gas is almost infinitesimal. When once the break-down voltage is reached, however, and it may be somewhat under 200 volts, depending on the design of the device, the current begins to flow. As soon as this occurs the neon is ionized; its resistance greatly decreases with a corresponding increase in carrying capacity. As the result of the lowered resistance, very high currents can be conducted by a trace of the neon, while in the case of other gases only moderate currents can pass. Unless subjected for a long period to the action of the current these devices are able to function many times, a small tube with gas at very low pressure, conducting as much as 10 amp.

Exhaustive tests in the laboratory have invariably tended to demonstrate that the accuracy and dependability of the neon type of lighting arrester is very much greater than that of any other arrester now known. If the results of experience in field tests parallel experience in the laboratory, there can be no question that an extensive commercial application of neon is assured for use in the lightning arresters alone.

The Interstate Commerce Commission has denied the petition of the New York, Chicago & St. Louis for a modification of the automatic train control order, to permit it to make the installation required between Conneaut, Ohio, and Brocton, N. Y., in lieu of the installation required in the commission's order.

A New Tunnel on an Electrified Line, Italy

Elementary Theory of Alternating Currents

A Series of Practical Articles Explaining a Difficult Subject in a Simple Manner

By K. C. Graham

Part IV—Further Consideration of Inductance and Capacity

AS mentioned previously, the effect of inductance, capacity or a combination of the two, is to limit the current flowing in the circuit so that it no longer follows Ohm's law which states that current equals volts divided by resistance. The effect of the inductance or capacity is known as reactance in that it reacts against the primary voltage of the circuit. What actually happens is that a counter voltage is generated which displaces the primary voltage to a certain extent thereby limiting the effective primary voltage of the circuit and, consequently, the current. It is easier, however, to consider that the

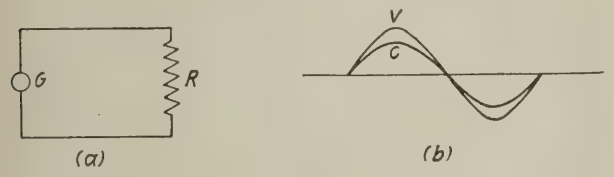


Fig. 30

reactance induces a spurious or false resistance into the circuit which when added to the ohmic resistance makes the total resistance such that the current really follows Ohm's law. For this reason reactance is always expressed in ohms and its method of determination will now be considered.

Inductive reactance, expressed Xi, is equal to $2\pi fL$ where π (pi) is a Greek letter denoting the figures 3.1416; f is the frequency of the circuit expressed in cycles per second and L is the inductance of the circuit expressed in *henrys.*

Capacity reactance, expressed Xc, is equal to $\frac{1}{2\pi fC}$ where the only unknown quantity is C which is equal to the capacity of the circuit in *farads.* The result in both cases is expressed in ohms. This is not added directly to the resistance of the circuit to obtain the total apparent resistance but must be combined with it in a way that we shall take up shortly.

It might be wondered how the above formulæ are obtained and it may be stated that they are the result of higher mathematical calculations which the reader may take up after he has mastered the fundamental principles.

It should be noted that as the frequency is increased the inductive reactance (for a given inductance in henrys) will increase because it varies directly as the frequency as may be seen from a perusal of the formula. Conversely it may be seen that the capacity reactance decreases as the frequency is increased. As a concrete example let us assume that the inductance is .02 henry and the frequency 60 cycles, then the reactance is 6.28 ohms. If the frequency is increased to 120 cycles the reactance becomes 12.56 ohms. Again, let the capacity reactance be .001 farad, then the reactance equals 2.65 ohms at 60 cycles. On increasing the frequency to 120 cycles the capacity reactance decreases to 1.325 ohms. Thus it is seen that inductive reactance varies directly as the frequency while capacity reactance varies inversely as the frequency. This fact results in peculiar conditions in circuits that contain both, as we shall see further on.

When an A. C. generator is connected to a resistor as in Fig. 30 (a), the current flowing through the circuit is in phase with the generated voltage as in Fig. 30 (b). As we learned a short time ago, the current would vary according to Ohm's law.

If the generator were connected to a circuit that contained only inductance in Fig. 31 (a), the current would lag behind the voltage to such an extent that it would be 90 degrees out of phase with it as in Fig. 31 (b). The reason for this will become more apparent from a consideration of Fig. 31 (c). It will be remembered that the voltage generated in any conductor or sets of conductors depends on the rate at which the lines of force cut across the conductor or conductors. Thus if a wire is moved across a magnetic pole at the rate of ten feet per second the voltage generated will be only half as great as when the conductor is moved at the rate of twenty feet per second. The same reasoning will of course apply if the conductor is stationary and the magnetic pole is moved across it. As the current varies gradually from maximum to minimum throughout the cycle the flux will vary with it, since the flux depends on the strength of the current. In Fig. 31 (c) it is seen that the base of the half wave is divided into six equal parts of 30 degrees each, these division lines being extended upward to the curve of

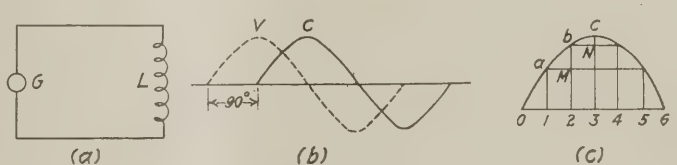


Fig. 31

current variation. These points of intersection are lettered *a, b* and *c,* and the lines of intersection are extended to the right. It may be readily seen that the distance *1-a* is greater than the distance *M-b* and that *M-b* is greater than the distance *N-c.* Now *1-a, M-b* and *N-c* represent the change in current for equal spaces of time *0-1, 1-2* and *2-3* and, since the changes in flux follow the changes in current, they may be taken as representing the change in the flux threading the turns of the inductance *L.* Now since the height *1-a* is greater than *M-b,* and that of *M-b* greater than *N-c* we may say that the flux is changing at a greater rate between *0* and *a* than between *a* and *b;* and that it is changing at a greater rate from *a* to *b* than from *b* to *c.* When the flux is changing the lines cut

across the conductors of L and generate a voltage in them that will depend on the rate at which the flux is moving across them. Therefore, the voltage generated while the flux is passing through the state of change from o to a will be the highest for the quarter wave while that between b and c will be the lowest. The nearer the zero or starting point of the wave the greater will be the rate of the variation of flux, the greatest variation being right at the zero point. Consequently this will be the point where the counter voltage induced in the inductance will be maximum. The nearer the maximum point of the current wave the lesser the variation in flux until, at the maximum point c the rate of variation is zero and the induced voltage will, naturally, be zero. The induced voltage wave is shown dotted in the figure. Here it is seen that the counter voltage is 90 degrees out of phase with the primary voltage wave (which the current follows). As the current decreases from maximum to zero the direction of the induced voltage will pass from zero to negative maximum as shown, this relation of voltage and counter voltage continuing so long as the generator is operating.

The condition present in a circuit containing only capacitance is as shown in Fig. 32 (a)-(b). It is exactly the same as in the previous figure with the exception of the fact that the current leads the voltage by 90 degrees

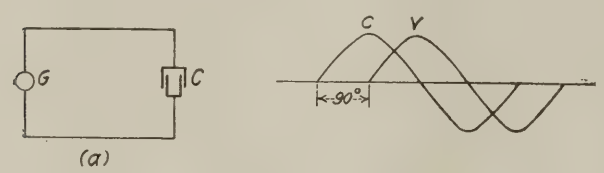


Fig. 32

instead of lagging behind it by 90 degrees as in the case of the inductance.

A circuit containing only inductance or capacity is purely imaginary and has only been considered for purpose of illustration because all circuits contain some resistance however small it may be. The truth of this assertion becomes readily apparent when we consider the fact that there is no perfect electrical conductor just as there is no perfect insulator; for all conducting substances offer some resistance to the passage of an electric current through them just as all so-called insulators will permit electricity to flow through them to a certain degree. Since there is no perfect conductor the turns of the coil which makes up the inductance of the circuit will offer some resistance to the flow of current. Therefore we may conclude that resistance must be considered at all times when considering the flow of current through a circuit that contains inductance, capacitance or both.

Since this is true we may now consider just how resistance is combined with inductance or capacitance to give an expression for the apparent resistance of the circuit that will enable us to determine the current flowing when any given voltage is applied. In Fig. 33 (a) R represents the ohmic resistance of the circuit while L represents the value found by multiplying the inductance in henrys by $2\pi f$. These two lines are at right angles because the resistance is considered as being in phase with the applied voltage while the counter voltage caused by inductance L is 90 degrees out of phase with it. Since 90 degrees is one-fourth of a circle or a right angle, as it is called, the two values are represented as shown, the relative lengths of the two lines R and L being equal relatively, to their respective ohmic values. The extremities of the two lines are joined by line Z which represents the combined value of the two. This value is called the *impedance* of the circuit and when the voltage is divided by this value the result represents the current flowing in the circuit. If the circuit contains capacitance rather than inductance the relation of R to C will be as shown in Fig. 33 (b), the direction of C being at right angles to R, but in the

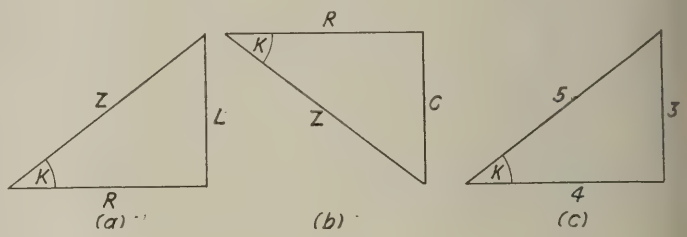


Fig. 33

opposite direction from that of L in the previous figure. This follows, of course, from the fact that the effect of L is opposite from that of C since the current lags in the case of inductance and leads in the case of capacitance. The value Z obtained in this case is used in the same way as that obtained in the case of the inductance to determine the value of the current flowing in the circuit. That this value is actually equal to the combined value of R and L or C may be proven very readily as in Fig. 33 (c). It is a well known proposition in geometry that the square of the hypotenuse of a right triangle is equal to the sum of the squares of the other two sides, the two sides being R and L or C while the hypotenuse is the connecting line Z. Thus if R is 4 inches long and L, 3 inches, then Z will be 5 inches because the square of 4, which is 16, added to the square of 3, which is 9, equals the square of 5, which is 25 thereby proving our formula to be correct. This may also be proved by drawing the figure on paper. Thus if the resistance of the circuit is 4 ohms and the reactance 3 ohms, the impedence will be 5 ohms, and if

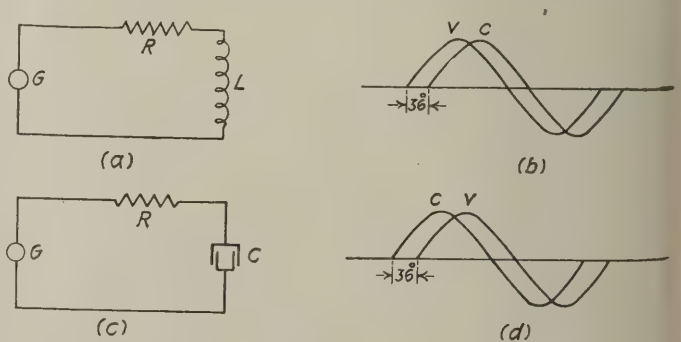


Fig. 34

the voltage is 100 the current will be 20 amperes. This current will lag behind the voltage by the angle K Fig. 33. This follows from the fact that the counter voltage of the inductance opposes the voltage and so prevents the current from following the variations in the voltage wave at the instant they occur. Another way of looking at this subject is to consider it in the following manner: The current that flows in a circuit must be the result of the pressure in the circuit at the time and therefore, current C in Figs. 31 and 32 must follow voltage waves that may

also be represented by curve C. We must conclude then, that there are two voltages active in the circuit—the primary or impressed voltage V, of the generator and the resultant or effective voltage that is in phase with the current C, and which is the result of the combined voltages of the generator and the reactance. It might be assumed that the counter voltage of the reactance partially neutralized that of the generator, but such is not the case because it adds the same amount to the generator wave at the finish of the half wave of generator voltage that it subtracted from it at the beginning of the half wave of generation. Therefore the effect of a reactance is not to absorb any of the generator voltage, but rather to throw it out of step with the position it would occupy if the

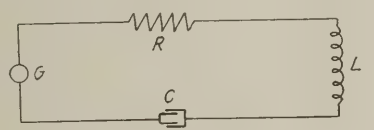


Fig. 35

reactance were not present. We shall return to this subject later in connection with the study of power, but shall let it drop for the present. From the foregoing it will be plain that the amount that the current is out of phase with the voltage will depend on the relative values of the resistance and the reactance of the circuit, while the current flow will depend on the combined value of the resistance and the reactance.

Fig. 34 shows the conditions represented in Fig. 33 (a) and (c), and illustrates a circuit containing resistance and inductance, the values being as shown in Fig. 33 (c). Fig. 34 (c) and (d) represent a circuit containing resistance and capacitance as in Fig. 33 (b).

There is still another case to consider; that of a circuit containing resistance, inductance and capacitance. This is represented by Fig. 35. Since the effect of inductance is opposite to that of capacitance it is only natural, as

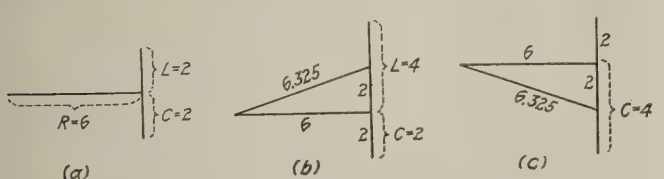


Fig. 36

previously mentioned, that the two would neutralize each other if they were equal in value. Thus a capacity reactance of two ohms will neutralize an inductive reactance of two ohms if the two are connected in series as shown in the figure. When this happens the circuit is said to be resonant and the only limiting feature of the amount of current flowing through the circuit is its ohmic resistance. This is shown in Fig. 36 (a).

Fig. 36 (b) shows the condition existing when the inductive reactance is four ohms and the capacity reactance is two ohms. The inductive reactance is neutralized to the extent of two ohms by the capacitance so that only two ohms of inductive reactance are active in the circuit. The same condition, with the exception of the fact that the capacitance is the greater of the two, is represented in Fig. 36 (c). The result is the same, however, regardless of which one predominates.

It is very easy to develop a formulæ for calculating the above by applying the knowledge gained in connection with Fig. 33 to Fig. 35. In Fig. 36 (b) Z squared equals R squared plus P squared. P is equal to L minus C. Therefore we may write our formula $Z^2 = R^2 + (L - C)^2$ or $Z = \sqrt{R^2 + (L - C)^2}$. The result of the condition represented by Fig. 36 (c) would be represented $Z = \sqrt{R^2 + (C - L)^2}$. If the capacitance of the circuit is zero (only inductance and resistance present) the formula would be $Z^2 = R^2 + L^2$. If the inductance is zero the formula becomes $Z^2 = R^2 + C^2$. If both are zero $Z^2 = R^2$, and $Z = R$.

As a numerical example of the above let the resistance of the circuit be 6 ohms, the inductive reactance four ohms and the capacity reactance two ohms, $Z^2 = 6^2 + (4 - 2)^2$, $Z^2 = 6^2 + 2^2 = 40$, $Z = \sqrt{40} = 6.325$.

If the inductance were two ohms and the capacitance two ohms then $Z^2 = 6^2 + (2 - 2)^2$, $Z^2 = 6^2 + (0)^2$, $Z^2 = 6^2$, $Z^2 = 36$, $Z = \sqrt{36}$, $Z = 6$.

Sanding and Stoning of Commutators*

In the article on "Grinding and Turning of Commutators," we discussed methods of trueing a new commutator or one on which the surface is in such condition that it cannot be put in good shape by the use of sandpaper or a hand stone. Where the surface is merely rough or dirty or where high mica is present there is no need of grinding or turning; sanding or stoning is an entirely suitable method of resurfacing a commutator in such condition. In fact, a hand stone, properly applied, will remove flat spots provided they are not of too great extent.

Sandpapering is a satisfactory method of cleaning a commutator that is not out of true and is considered by some engineers as the best means of polishing a commutator after trueing by some other method. However, it cannot be depended on to remove flat spots even of small extent. While it may appear to eliminate them, the effect is merely to broaden out the spot so that it is no longer apparent to the eye. Such a condition will have to be corrected by stoning or, if spots are very wide, by grinding or turning. In bad cases of high mica a stone will also be found superior to sandpaper.

In sandpapering a commutator do not use a paper of too coarse grain. It is better to select a rather fine grain and take longer to do the work. In this way deep scratches will be avoided and subsequent operation improved. If sandpaper is used for putting the final polish on the commutator a very fine grain should be selected. Further improvement in results will be attained by attaching the paper to a block of wood cut to the radius of the commutator to be cleaned.

One of the principal objections to the use of sandpaper for cleaning a commutator is that it very rarely leaves the bars properly round. On an unslotted commutator, particularly where the mica is high, the sandpaper has a tendency to flatten the center of the bars. This can be partly counteracted by the use of a moderate amount of oil on the paper. This tends to make the mica cut more readily and reduces the cutting effect on the copper. It should not be used in excess or it will work into the mica, carrying particles of copper with it, and short circuits will result.

On a slotted commutator sandpaper even when used on

*Abstract of a bulletin published by the National Carbon Co., Inc.

a block rounded to fit the commutator has a tendency to flatten or bevel the edges of the bars. Oil should not be used when sanding a slotted commutator as it will cause the copper dust and sand to collect in the slots, while if no oil is used the centrifugal action will throw the dry dust from the slots.

Emery paper or emery cloth should never be used on a commutator, especially when it is being cleaned with the current flowing through the armature. The reason for this is that emery is an electrical conductor and particles are likely to become imbedded between the segments and cause short circuits.

A hand stone has advantages over sandpaper as a means of cleaning a commutator providing a stone with smooth, fine grain and free cutting properties is selected. Its lack of flexibility eliminates the tendency to flatten the commutator segments which often occurs when sandpaper is used. As with sandpaper, it is best to form the stone to the curvature of the commutator. In this way the tendency to gouge and pit the commutator surface is reduced. Moreover, the stone thus bridges over any small flat spots in the commutator and completely eliminates them instead of just broadening them out. Considerably worse commutator conditions can be corrected with a stone than with sandpaper but eccentricity or broad flat spots can only be removed by grinding or turning. The limitation to the use of a hand stone is the question of whether or not it can be kept from jumping as the inequalities of the surface pass under it.

Where it is possible to arrange a good rest for the stone, it may be used as a hand turning tool and flat spots removed which could not be permanently removed by holding the stone flat against the commutator. With this method a much smaller area of the stone is brought in contact with the commutator than in the previous method.

If too large an area is in contact the stone will slide over the surface instead of cutting steadily and the object of using this method is defeated. Hand turning with a stone requires considerably more skill on the part of the operator than where the stone is held flat against the surface. The support must be very rigid or vibration of the stone will occur and small pits and holes be dug in the surface.

Unless the operator possesses sufficient skill to use this method properly, he had better resort to grinding or turning to correct conditions that are too bad to be eliminated by a stone held flat against the surface.

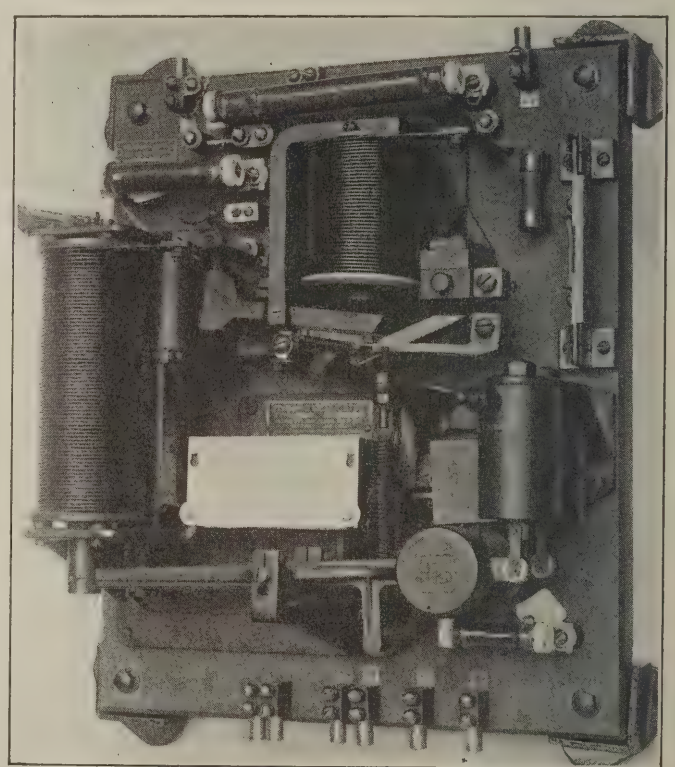
When sandpapering or holding the stone flat on the commutator it is best to run the armature at normal speed. In hand turning with a stone, it may be better to reduce this speed somewhat. This can be determined by experimenting to find the speed at which the stone cuts most freely.

In any method of finishing a commutator surface, one thing that must be avoided is diagonal scratches on the finished surface. This is especially true if strictly non-abrasive brushes are to be used as it may take such brushes several weeks to polish out these scratches. Diagonal scratches on a commutator fill up with fine particles of carbon and give it a dull and dirty appearance. Furthermore, if the edges are rough, they may be a cause of unnecessary brushwear. A stone is superior to sandpaper in this respect for commutator surfacing, as the particles from the sandpaper are coarser, free themselves more readily and rolling out to the side, form more diagonal scratches than are formed by the more firmly imbedded and relatively smaller particles of the stone. For the same reason, it is important that the side to side movement be slow in either sanding or stoning.

After finishing, the commutator should be wiped off carefully to make sure that all particles of free copper have been removed and the armature should be blown out thoroughly. It is also well to make an electrical test for grounds before putting the armature back in service.

Universal Generator Regulator

Among the new devices recently brought out by the Safety Car Heating & Lighting Company, New Haven, is an arrangement on the back of car lighting generator regulators making them interchangeable regardless of their capacity and resulting in a reduction in the number of parts to be carried in stock. The current regulating coil and main switch series coil are wound for 25 and 50 amperes capacity only, but the connections are so arranged that a regulator with 25-ampere coils can be set for either



The Universal Regulator Is Suitable for a Wide Range of Current Control

25 or 40 amperes and the regulator with 50-ampere coils can be set for either 50, 75 or 100 amperes.

When these improved generator regulators are applied for use with generators having capacity less than the maximum setting of the regulator, a fibre cap is applied to the cut-out stud so that the regulator cannot be set above the maximum capacity of the generator. If it is later found desirable to use a higher capacity generator with the same regulator, maximum setting is obtained by substituting a brass cap in place of the fibre cap.

Contracting for Electric Power Service

Suggested Form of Contract Which Provides for Power at Cost with Increasingly Better Service

By Sidney Withington
Electrical Engineer, New York, New Haven & Hartford R. R.

THE practice has gradually developed, in making contracts for electric power, to base the price on what amounts virtually to the cost of production. This is on account of the fact that government agencies generally have assumed jurisdiction over the rates of return on capital investment in public utilities companies. It would in many ways be of advantage to go a step further and base large power contracts on actual production costs, and the following notes are presented with a view to stimulating discussion on this question.

The usual form of contract for steam-generated electric power under present conditions consists of two principal parts, (1) "Primary" or "Demand" or "Service" charge based on the maximum demand received over a given period (usually five minutes, fifteen minutes, thirty minutes or an hour), and (2) "Secondary" or "Energy" charge based on the quantity of energy actually used.

The primary or demand charge is intended to cover fixed charges such as depreciation, interest, taxes, prorated on the basis of that portion of the power plant, equipment, and other facilities set apart for the use of each customer. It is contemplated that out of this portion of the power charges the stockholders will obtain the return on their money invested and pay interest on borrowed money.

The secondary or energy charge usually represents approximately the production cost (maintenance and operation) with the addition of an item to cover all contingencies which can be foreseen.

Within the last ten or fifteen years there has sprung up the custom of including in addition to the primary and secondary charges, a provision to cover fluctuations in the cost of fuel, which it is now recognized cannot be accurately predicted from year to year. In some instances also variation in labor rates is recognized and provided for by an appropriate provision.

The principal items which go to make up the cost of power production are thus recognized in important power contracts and the price of the power is virtually based on cost, on account of state regulation. However, an important item is left largely to chance, and the large consumer is likely to lose a consideration of considerable value when on account of improvement in the art of power production, facilities of increased efficiency are developed and installed. Furthermore, the power company is quite likely, in figuring its power costs, to err on the safe side in considering contingencies, many of which are extremely improbable.

Consumer Would Benefit

It is thus evident that if a contract were made for power *at actual cost*, it would be of benefit to the consumer and should not be of any disadvantage to the power producer. The developing of such a contract, and defining actual power costs, should not present serious difficulties. In fact, the present method of determining prices is based to a very large degree on the solution of many of the problems which would be involved. For instance, it is in general from the primary or service charge (based on the

pro rata demand of each consumer) that the owners of the property and the bond holders receive a return on their money. Indeed, this return or interest rate is now fixed in many localities by the public utility regulatory bodies.

There are two general methods of regulating the dividend rate of public utilities properties. The more common one is to fix a percent of the capital invested which it has been determined is fair under the local conditions. The interest rate having been determined, the power rates are naturally fixed automatically to allow this rate to be paid. Increased economy of production is reflected only in lower rates for power. The other means of interest regulation consist of a sliding scale, the return to the stockholders being an inverse function of the rate to the consumer. This method, of course, to be fair, must take into account fluctuations in cost of material and labor items over which the utility company does not have control. These components, however, may be readily determined and allowed for. This method has a distinct advantage over the other in that it leaves an automatic incentive on the part of the utility company managers to continually endeavor to increase the efficiency of power production and distribution.

Depreciation Provided For

Not only must the stock dividends and bond interest be paid from the primary charges, but an allowance must be made for depreciation, and this is one of the more intricate problems of determining actual cost. The problem, however, exists to as great an extent in determining power rates at present as it would if power were to be furnished strictly "at cost."

"Depreciation" arises from three sources, (1) wear-and-tear, (2) inadequacy and (3) obsolesence. A machine or other property is retired from service if it is worn out; if it becomes inadequate on account of growth of requirements of the service to be performed; or if it becomes obsolete on account of increased efficiency of more modern apparatus. While each of these three sources may be entirely distinct from the others as a cause of removal from service, nevertheless all three operate fundamentally in exactly the same manner and there is usually no occasion to differentiate.

When a unit of a plant has become unserviceable from any cause and must be replaced, the investment represented by it (less the salvage value) ceases to be a portion of the capital used for the production or distribution of power. The cost of the new unit cannot be added to the cost of the original one, but must replace it. The loss in capital over a period of years is a part of the cost of production during that time. Depreciation may thus from some points of view be considered an operating expense.

The most usual method of meeting this problem is this: When a facility is retired from service there should have been money set aside which, added to the amount that the facility is then worth either as second-hand or as scrap material, is sufficient to pay for its replacement in kind. Contributions to this replacement fund should be made regularly, in order that the total value of the property may not diminish. The amount of this periodic contribution is based fundamentally on the probable life of the apparatus, which is a matter of judgment or estimate.

There is now, unfortunately, no generally accepted basis for estimating the probable life of various component parts of power generating and distributing facilities. There is, however, a vast amount of information available and it should be relatively easy for an unprejudiced body of technically experienced men made up of representatives of power companies, large power consumers and public regulatory bodies, to get together and agree as to the probable life (considering, of course, all three items—wear-and-tear, inadequacy and obsolesence) under various typical conditions, to be used as a guide in determining depreciation.

Of the three factors in depreciation (wear-and-tear, obsolesence and inadequacy), one or another will determine the life—the question is, which? This affects the salvage value estimated. All figures which are set up by a joint committee should fully explain how they are developed, if they are to be of value in individual instances.

The actual life of any individual building or machine or boiler or transmission line or duct line or cable may not, on account of local conditions, correspond exactly to the average expected life as set up, but in the long run there is little to be feared with respect to such inconsistencies, and as conditions change from time to time and additional information is available there is nothing to prevent a modification of the assumed average term of life for the various items.

Having developed in an entirely impartial manner, for the guidance of the power company manager, an average presumed useful life for each important part of his property, and a presumptive residium or salvage value, the depreciation charges are readily calculable. It is to be noted, however, that the periodic charges or contributions to the depreciation fund should not usually be made (as they are generally made at present) on a "straight line" basis, that is, by dividing the total desired amount of the fund by the pre-determined life of the facility, for the fund is not idle while it is in the making, and each contribution is immediately put to work as soon as it is made, and thus earns interest. The amount of these periodic contributions, whether monthly, quarterly, semi-annual or annual, should logically be determined on an annuity or "sinking fund" basis, such that with the interest added, the final desired amount will be reached at the end of the allotted time. The compounding should, of course, be figured as often as the contributions are made.

A Fund for Making Needed Improvements

The reserve or depreciation fund as it accrues may be invested in the concern for extensions in the plant or it may be invested outside in readily convertible securities. In either instance the fund represents the gradual loss in capital of the physical plant, and in either instance the fund is usefully employed and is thus earning interest. This is entirely satisfactory if there is not to be a sale or reorganization of the property during the period under consideration.

In developing the amount thus to be set aside for the depreciation fund each year, the property should be divided into its various component units and the life of each unit estimated separately. The contribution to that part of the fund represented by a given unit is thus based on the assumed life of the unit and its salvage value; and total contribution to the depreciation fund is merely the sum of the individual contributions.

There are other ways of taking care of the depreciated value of facilities, some of which do not require an estimate of the life of the units or of their salvage values. If there

were a sudden unexpected growth of demand for service or a radical improvement of production standards which made it imperative or desirable to replace relatively new facilities it might conceivably be logical to impose the burden of the amortization wholly upon those benefited by the replacement. This may, however, be dangerous as compared with the principle of paying for the facility as it is used.

There are those, however, who advocate this method of taking care of depreciation. It is claimed that it has the advantage that when a facility is removed from service its length of life and its salvage value are known and the amortization is therefore definitely fixed. There is no necessity for estimates which may or may not be accurate. If an organization is growing rapidly this method may give rise to some complication in financing.

If the units of a facility are relatively small in cost as compared with the annual budget, it may be satisfactory not to maintain any depreciation fund but to charge all replacements against operation. This, of course, reduces the accounting complications a great deal, but there is some danger that it may overburden the expenses if extra large replacements are made in any one year.

It matters little in the long run how the depreciation item is figured in calculating cost of power, providing whatever method is used is followed logically to its conclusion. The problems involved all exist and must be solved regardless of how the power is to be sold.

In addition to the interest and depreciation charges, the items of taxes and insurance may be included in the fixed or primary charge. These charges are readily determined, as they are actual expenditures. It is, however, perhaps more reasonable to consider insurance premiums under "Operation" than as part of the fixed charges, that is, to figure them as part of the cost per kilowatt-hour rather than as part of the cost per kilowatt, as the insurance premium, from a cost standpoint, replaces over a term of years the occasional catastrophe.

Having thus determined the aggregate fixed or capital charge, each large consumer should pay a pro rata amount based on the proportion which his demand bears to the total demand on the plant facilities. The cost surplus capacity which is necessary to assure reliable service and allow for contingencies is thus divided among those who benefit by it. This ratio which each consumer pays, of course, varies from time to time, and an average figure must be arrived at.

An exceedingly important consideration should be noted, especially in connection with power for electric traction purposes, where it may be impossible on account of various contingencies to control the demand. The company supplying power should agree to furnish such capacity as may be available upon emergency and at a cost which is commensurate with the service rendered and which does not penalize the consumer. A railroad may occasionally experience extreme traffic congestion on account of a wreck or other interruption, and it is that kind of emergency in which the power company should be willing to assist with its surplus capacity at reasonable cost.

A further consideration of importance in this connection is that of power factor. The consumer who provides a load with a favorable power factor should not be burdened with the cost of providing facilities for the customer whose power factor is low. An incentive should be provided to the consumers to provide loads with as high a power factor as possible, even at the expense of added apparatus to bring this about. Many power companies now take cognizance of this and the problem would not be further complicated in "power at cost" agreements.

The method of arriving at the secondary or energy cost on the basis of actual cost is very simple. The unit cost is merely the total aggregate expense of operation and maintenance divided by the total output in kilowatt-hours. Some arrangement, of course, must be made to differentiate between day-to-day or ordinary maintenance or replacement items, and items which should be taken care of by the depreciation fund. There is in general a fairly sharp line of demarcation, but it is nevertheless true that there is a twilight zone which must be accurately defined in order to avoid misunderstanding. This may be done in a number of ways, any one of which should be entirely satisfactory to meet all conditions. Some work in this direction has already been done by government regulatory bodies.

The transmission losses should, of course, be paid for by the consumer. These can readily be calculated.

It is true that the large consumer is a more attractive customer than the small one, and the unit price of power to him may therefore logically be somewhat less. This factor can readily be taken into consideration in figuring the costs in any one of a number of different ways, perhaps by an equitable contribution to the surplus account which is maintained to take care of "lean" years.

Conclusion

The furnishing of power at actual cost will give the large consumer the benefit of increased economies in production as they are developed and obviate the necessity on the part of the utility of setting up a generous item estimated to cover contingencies which may never arise, and the benefit of which is obtained, if they do not occur, by future consumers who have had no part in contributing to the surplus which is thus attained.

Under a system of contracts for power at actual cost a more accurate method of determining depreciation should be developed. There are various methods of solving the problem, but a standardized method should be arrived at. This can best be done by a joint committee on which are technical and accounting representatives of power companies, consumers and public regulatory bodies. There is ample information available for the use of such a body, and the results of its action (which should be entirely unprejudiced) would be of great value as a guide in determining rates, even under present day conditions.

The fixed costs and energy production costs will both necessarily fluctuate from time to time as power costs fluctuate, and the consumer cannot definitely know in advance exactly what he will be obliged to pay for power. This, however, is true today even in "fixed price" contracts, practically all of which contain coal adjustment clauses and many of which contain labor adjustment provisions.

The centennial of the Baltimore & Ohio Railroad, which will be celebrated in 1927, has been made the subject of a joint resolution in the Legislature of Maryland, under which the governor of the state is authorized to appoint a commission of seven members, to serve without compensation, to co-operate with the railroad company and the city of Baltimore in conducting a suitable celebration. The charter of the railroad company was granted on February 28, 1827.

Superpower Report Made Public

ELECTRIFICATION of transportation in the northeastern section of the United States need not lag if adequate means of generating power are provided for, according to the conclusions reached in the report of the engineering sub-committee of the Northeast Superpower Committee made public Monday, July 28, at the Department of Commerce. Herbert Hoover, secretary of commerce, is chairman of the committee. The report states that the increasing electrical power demands of the northeastern area of the United States, if they are to be supplied on an economical and adequate basis, necessitate the extension of interconnection between the different systems, the building of large, centralized, steam-electric plants located at strategic points and the development of the large hydro-electric projects.

These recommendations, in the committee's opinion, will mean the saving of over 50,000,000 tons of coal every year; production of power at less cost; security in power supplies against interruption with its losses through disturbed production and unemployment; larger reserves of power through which other industrial development need not lag, awaiting power construction; electrification of transportation with increase in its efficiency; extension of power uses to the farm and saving of human effort.

The present report is an outgrowth of a conference held in New York City last October, with the consent of President Coolidge, between Secretary Hoover and the chairman of the State Utilities Commission of the eleven northeastern states. This conference led to the formation of the Northeastern Superpower Committee, composed of representatives of the states and of the federal government. While others were engaged on the legal questions involved, an engineer sub-committee undertook a comprehensive survey of the technical aspects of superpower development in the states affected. Their report, now given to the public, will be referred to a meeting of the full committee to be held some time next fall.

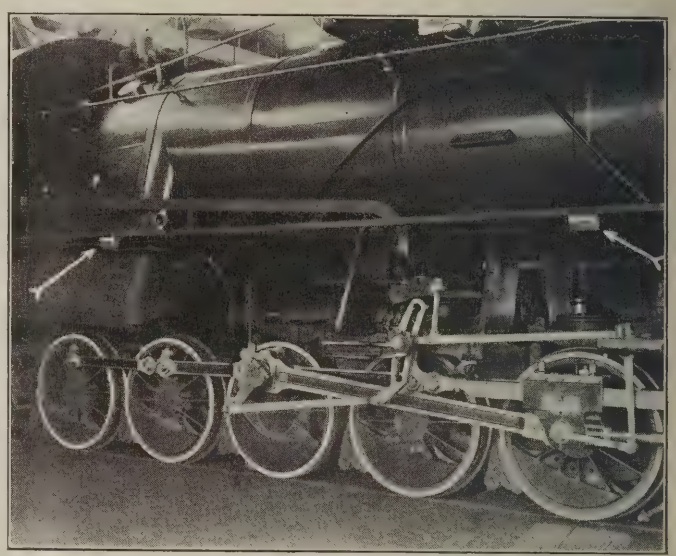
The survey of power facilities and power needs made by the engineer sub-committee covers the states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland and the District of Columbia. There has been included also some reference to the states of Ohio, Virginia and West Virginia, since under certain circumstances power in these regions will be contributory.

Five charts which accompany the report are of particular interest and value to the prospective users of power as well as those who are interested in power development. The first chart shows steam power developed, projected superpower steam stations, hydro-electric power developed, potential hydro-electric power, soft coal fields, and hard coal fields. The second chart shows the distribution of present power consumers with an estimated increase for 1930. The third includes a layout of existing transmission systems. The fourth shows existing transmission lines of 110,000 volts and over and indicates certain new lines that will be necessary to bring power from possibly cheap sources of production to the larger load centers. The fifth chart divides the northeast section of the country into areas and makes a comparison of costs of power from various sources.

The report as a whole contains a concise and a straightforward statement of what the Department of Commerce hopes may be accomplished by interconnection of power systems in the northeast section of the United States. The report indicates growth in the use of electric power for industrial and other purposes. It recommends extension of interconnections between different systems, construction of large steam plants strategically located, and development of large hydro-electric projects.

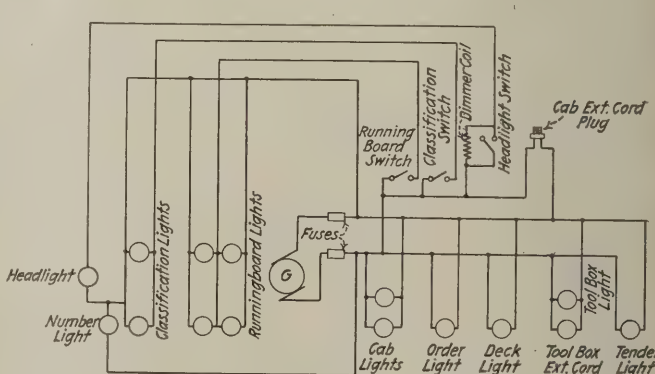
D. T. & I. Locomotive Wiring and Lighting System

THE Detroit, Toledo and Ironton Railroad has given the term "standard equipment" a broader significance as applied to locomotive. In addition to such special features as aluminum cab floor, large windows, cushioned seats and nickeled fixtures, there is the lighting system.



Arrows Point to Running Board Lights Which Will Be Standard on All Power

A railroad locomotive is popularly believed to carry about the same number of lights as an automobile. Investigation of a standard D., T. and I. Railroad engine will show that it is equipped with fifteen lights and plugs



Wiring Diagram for D. T. & I. Locomotives

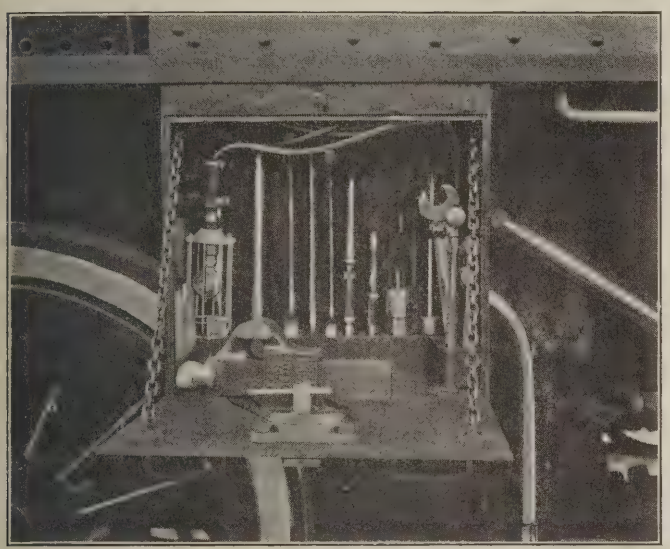
for extensions. Many locomotives have approximately ten lights and trouble plugs.

Complete locomotive lighting system greatly enhance the ease and safety with which firemen and engineers may perform their duties.

The newest addition to the lighting system on D., T.

and I Railroad locomotives is two lights under the side running boards. The purpose is to afford illumination at night for oiling and inspection, incidentally doing away with the obnoxious torch formerly used by engineers. The bulbs are inclosed in cast-aluminum frames which also serve as reflectors. This equipment is installed on locomotives while being repaired.

The D., T. and I. Railroad standard tool boxes, fastened to one side of the locomotives, near the cab, have a working light connected to an extension cord, affording convenient illumination in time of trouble. A plug for another extension cord, thirty-five feet long, is located in the cab. Within easy reach of the engineer are switches for the



Tool Box to Be Standard on All D. T. & I. Locomotives—This Box Is Already Installed on Three-fourths of the Locomotives

running board lights, order light, classification light, headlights and two gage lights. One gage lamp was eliminated by placing three gages on one bracket.

The switch engines have two lights on the rear of the tender. One is a headlight and the other illuminates the footboard, assisting trainmen to find the step in the darkness. The headlight may be dimmed.

The wiring plan is simple, and avoids use of an unnecessary length of wire. Flame-proof No. 14 wire is used, insulated with asbestos and rubber. The bulbs are all 15-watt, 32-volt rating, except the headlights, which are 250-watt, 32-volts. Sunbeam turbo-generators are used. After turbines pass successful tests for speed and voltage, they are sealed to prevent tampering while locomotives are on the road.

Diesel-Electric Tugboat for Pennsylvania

THE first Diesel-Electric tugboat ever built was recently completed by the Pennsylvania. The steel hull was constructed at the Staten Island Shipbuilding Yards and delivered to the Pennsylvania at its Hoboken Marine Yards where the propelling machinery was installed and the tug outfitted. The boat which is known as "P. R. R. Tug No. 16" is now receiving its dock and river trials on the Hudson River and Upper Bay.

The principal parts of the propelling machinery consists of two Winton-Diesel oil-burning engines, each operating a Westinghouse generator to supply current for a 575 hp. motor, turning the screw propeller. The pilot has direct control of the propelling machinery as well as the steering apparatus and signals to the engine room are eliminated.

The tug is 105 ft. long and has a 24-ft. beam and draws 12 ft. of water. It will be used for general purposes in

P. R. R. No. 16

New York Harbor, including the handling of car floats between Jersey City and the various terminals of the Pennsylvania System. It will also be tried out between Cape Charles, Md., and Norfolk, Va., for the purpose of developing similar tugs for service between these points.

Two New Switches

Two new devices have recently been added to the line of the Bryant Electric Company of Bridgeport, Conn. One of these is a shallow push button switch which is made single pole, double pole, three and four point styles. The depth of this switch is 1 7/32 in. from the outside of the yokes to the backs of the porcelain cups. The contact terminals are held with two screws which is an improvement over the ordinary switch construction which employs

Shallow Push Button Switch

Lock Type Tumbler Switch

only one screw per terminal. The current carrying parts are insulated from all other metal parts.

The second device is a lock type tumbler switch which has a fibre shield slotted to receive the actuating key. This switch is intended for hallways, waiting rooms and for places where it is desired that only those persons having the proper keys may operate the lights. These switches can be obtained in single pole, double pole, three point or four point styles as desired.

A Method of Cleaning Enameled Steel Reflectors

By Louis D. Moore

Enameled steel reflectors used about roundhouses, coaling stations and similar smoky locations soon acquire a coating of carbon which it is practically impossible to remove by ordinary methods. In an increasing number of cases reflectors are being installed which have a cast or other hood and removable reflector, and where such removable reflectors are in use the following method, which has been successfully tried on the Missouri Pacific, will be found effective.

The reflectors are placed in a suitable receptacle, such as a metal drum, containing water and "soda ash" (carbonate of soda or "sal soda") in the proportions of about one gallon of soda ash to twenty gallons of water. They are then boiled in this solution for about fifteen minutes, either by putting a fire under the receptacle or by use of live steam, after which they are removed, rinsed thoroughly in clear water and dried. They will be found to be restored to their original whiteness, without any damage to the surface of the enamel.

Where one piece reflectors have been salvaged they may be made as good as new, so far as the enameled surface is concerned, by the above process, immersing both reflector and socket in the solution. The cleansing effect is noticed on the sockets as well as the reflector.

An Unusual Case of Motor Heating

By A. Foreman

Some time ago I had occasion to investigate a 20 hp. 3 phase squirrel cage motor of popular make, that became so hot that the insulation began to smoke after a run of three or four hours. The motor had been pulling the load for several years without any apparent trouble but the foreman said that he had noticed the fact that it had been gradually running hotter and hotter for quite some time past, until, at last, it reached the point when it started to smoke.

I started the motor up without load and it appeared to run normally. After a 15 minute run I shut it down and felt over the winding to see if I could detect any hot coils. I also examined the rotor for loose bars and as no trouble was located here I naturally inferred that the motor was overloaded due to some defect in the more or less complicated apparatus that it was driving. The load was applied, a current reading taken and the motor was found to be slightly underloaded rather than, as I had suspected, overloaded. Therefore I decided to load the motor for a period of two or three hours and to examine it thoroughly at the end of this time so I had the load applied and went to another part of the plant to do some other work meanwhile.

Upon returning at the end of an hour and a half I found the motor abnormally hot. I immediately took another current reading to convince myself that the load had not increased in some manner or another but found that the load had not changed in the least. The motor was shut down and the winding, together with the rotor, thoroughly examined for points that were not of the same temperature but nothing unusual was noted except that the winding was hot all over. As this told me nothing I decided to dismantle the motor to see if anything should present itself. Upon removing the rotor I noticed that the slots were closed by means of magnetic (iron) wedges. I casually touched one of them and almost blistered by finger before I could withdraw it. This then I decided must be, undoubtedly, the source of the trouble and further investigation proved this conclusion correct. I found practically all of these wedges grounded, vibration having worn out the thin paper insulation that separated them from the iron laminations. These grounded wedges provided a low resistance path for eddy currents in the laminations, particularly at the surface, thus giving rise to enormous currents which caused heating of the whole machine.

After reinsulating the wedges the motor was found to operate at a temperature hardly to be designated as warm.

The Better View

Now and then some bird will wail, and squawk a most depressing tale; of morals on the slump: he's sure that soon we all shall ride upon a steep toboggan slide, and wind up with a *bump* . . . . Old age has quenched his youthful fires, or else he has suppressed desires, which fear Convention's wrath; because beneath his thin-skinned hide, he longs to cut a swath that's wide, along the primrose path . . . When e'er I hear this type of goof, I long to *Lift* him with my hoof, I want to clout him quick, for only constipated owls, can hoot such pessimistic yowls —when they *think* the world is sick.

I've watched the flapper and her sheik; she's not just what one would call meek, in these jazzy—bim-bam days: perhaps she smokes a cigarette, and gulps the drink which she can get, by artful Sheba ways . . . But she will mother a new breed, and *tolerance* will be their creed; they'll face life with a song: when they hit life's rocky

road, and lift from us our heavy load, *the world will wag along*. . .

I'm told our business men are hogs, they'll drive the country to the dogs, for they act like Feudal Lords: the common runt is now so poor, he can't buy Packards any more, and has to ride in Fords . . . The gink who copped things with his hooks, and chummed around with other crooks, maybe flourished ages back, but such methods rank and crude, are little things which now preclude, annexing surplus jack . . . Anyone can cop some kale, and waste no time in dodging jail, or hiding in the woods, if he will simply use his bean, in a business which is clean, and deliver up the goods . . . I find that things are on the mend, that we do business with a friend, that both are shootin' square, that facts surrounded by a haze, and all old underhanded ways are getting scarce and rare.

So when you hear some buzzard wail, and start to puke a dismal tale: just figure he is dense: listen to the birds that *sing*, in fact do almost any thing, which restores your confidence.

A Fable

In the days succeeding the Centaur, when horses, mules and asses were used as the propelling power of vehicles to transport humans, gates were used to stop travelers on the highways when a railroad train approached. The horses, mules and asses, seeing the gate across the road, stopped and let the train go by in safety to themselves.

In the progress of mankind motor vehicles were produced, and then the ass, instead of drawing the buggy, climbed into the front seat and became the driver of the flivver. Since that time he has usually been unable to see a gate at a railroad crossing, and if he did occasionally glimpse it, it was his delight to run it down in trying to beat the train across the track.

Moral—Keep the ass in his place.—*Daily Journal Press, St. Cloud, Minn.*

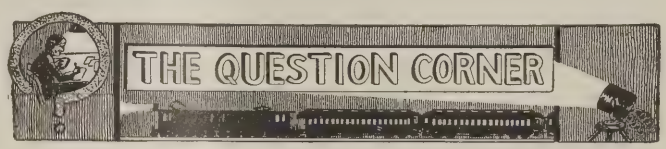
Appreciation

He was whistling at his work
With a grin upon his face.
Not a solitary shirk
Seemed to loiter in the place,
But this youth who caught my eye
Seemed to glory in his task,
So I stopped to find out why
And this question paused to ask:

"Tell me this, my cheerful lad,
As you whistle at your bench,
Why is it you seem so glad
To employ that heavy wrench?
Why so earnestly today
Do you labor at your task?"
And he looked as though to say:
"That's a foolish thing to ask."

Then he answered with a grin
As he laid aside his wrench.
"Just today the boss came in
And he stood beside my bench
And he spoke to me like you,
Then took up this work of mine,
Looked it over, looked it through,
And then said, 'It's simply fine!'

"You can talk about your pay
And the pleasure of a raise,
But I'm telling you today
That a little word o' praise
From the man you're working for
Does a fellow lots o' good
And it makes him, more and more,
Want to keep on sawing wood."



Answers to Questions

I have an induction motor of the following construction; stator, 3 circuit, delta; slots 180*; pitch* 1 *to* 12*; conductors* 6 *per slot; rotor* 1 *circuit Y; slots* 142*; slip* 5 *per cent; conductors* 2 *per slot; r.p.m. full load* 585. *I would like to secure the following information,—What is the secondary voltage when the rotor is locked? When the rotor is not locked and starting up under light load? When starting up with heavy load? How would a person go about a test to obtain this data?—C. T. G.*

Induction Motor Relations

If the motor were a good transformer, the secondary voltage with the rotor locked and with full voltage applied to the stator would be approximately 600 volts, but due to magnetic leakage, which is very high when the motor is locked, the secondary voltage would be materially lower and would probably be around 500 volts. When the motor is operated at 585 r.p.m. the secondary voltage would probably be in the neighborhood of 40 volts. When starting with light load or with heavy load, the secondary voltage is the same, provided the same primary voltage is used. If started on full voltage, the secondary voltage in either case corresponds to the locked secondary. If started on a reduced primary voltage, the secondary voltage is reduced in like proportion.

To determine the secondary voltage values for this motor, it may be operated on reduced voltage, say 110 volts, with the rotor blocked and readings taken on the secondary voltage with the voltmeter. The value thus obtained on 110 volts would be approximately one-fourth of the secondary voltage with locked rotor under full primary voltage. The secondary voltage under running condition can be read directly by means of a voltmeter, provided the latter is suitable for a low frequency circuit, as the secondary frequency at 585 r.p.m. would be three or four cycles.

Questions for August

1. *Can you tell me which country has the most powerful electric and steam locomotives and the tonnage they can pull?—C. B.*

2. *What is meant by a storage battery being in a "starving" condition?—M. L.*

A Composite Welding Electrode

An arc welding electrode of unique construction was recently brought out by the General Electric Company. It consists of a flux coated central metallic core, which is enclosed by an outer metallic layer or sheath. The sheath prevents the flaking off of the flux in handling and insures against dissipation of the flux by the arc. The desirable characteristics of the electrode as listed by the manufacturer are stability of the arc, with the resultant ease of manipulation; rapid deposition and good penetration; sound, tough welds made without the necessity of removing the slag of previous layers; maximum economy resulting from high welding speed, small amount of power consumed, small amount of metal for required strength and high quality and reliability of the weld.

The electrodes are supplied in four sizes, 3/32, ⅛, 5/32 and ¼ in. in diameter. The coating of flux between the core and the sheath is 2½ thousandths of an inch thick. It is shipped in coils or reels, or is straightened and cut to either 14-in. or 22-in. lengths, and supplied this way in 50-lb. bundles.

A Tapered Arc Welding Electrode

Taperod is the name which has been coined to describe an arc welding electrode which is smaller at one end than at the other. It is a development of the Electric Arc Cutting & Welding Company of Newark, N. J. The purpose of this form of rod is to provide for the undesirable heating of the electrode. As the heat develops in welding, the uniform increase in the thickness of the tapered electrode provides heat compensation along its entire length. The heating of the rod due to resistance loss is compensated for by the larger diameter of that part of the electrode which carries the current the longest. The manufacturer states that the gradually increasing diameter of the electrode allows a corresponding increase in deposition with a constant heat value in the work while waste ends are reduced to a minimum because the rod does not become red hot as it becomes short.

The electrodes are tapered by a rolling and swaging process and are coated after being shaped. The rolling and swaging is an added factor in the process of manufacture, but the price of the tapered rods is not to be increased above that of the straight flux coated electrodes manufactured by this company. Taperods are made from a variety of materials for all kinds of electric arc welding. They are made in one size only: ⅛ in. in diameter at one end and 5/32 in. at the other.

Welding Material for Building Up Worn Surface

High carbon electrodes and gas welding rods made for building up worn surfaces on high carbon steel parts, such as battered rail ends, steel tires, buffer castings and switch points, were recently introduced on the market by The Page Steel & Wire Company.

When properly used, the metal deposited from the rods will show a carbon content varying from .60 to .80 with a corresponding scleroscope hardness varying from 30 to 37.

The gas welding rods are furnished in 36-in. lengths and in four sizes: 5/32 in., 3/16 in., 1/4 in. and 5/16 in. in diameter. The electrodes are supplied in the same sizes and in either 14 in. or 36 in. lengths. In direct current electric arc welding the high carbon electrodes are used on the positive side, where Page Armco electrodes are used on the negative side. The finished weld made with either the gas welding rods or electrodes may be ground, but is not readily machinable.

Enclosed Switch with Maximum Safety

The National Board of Fire Underwriters through its laboratories in Chicago has recently given its official approval of the principle and design of the safety type switch as manufactured by the Super-Safety Electric Company, Chicago, and has given this switch the AA classification for both fire and accident, this rating being the highest attainable for a switch device.

The foundation of this device is a base piece of insulation having compartments, covered with a plate or shield which is slotted to permit the free movement of blocks of insulation which set into and move out of these compartments as they are turned by the handle attached to a square shaft passed through these blocks. Upon the faces of the blocks are contacts and fuses. Upon the ends of each compartment in the base piece are fixed receiving contacts with which the movable contacts on

the aforesaid blocks engage, thus making and breaking the circuit as the handle is turned.

Reference to the illustrations will make this clear; thus Fig. 1 shows the blocks face down and switch "on"; Fig. 2 shows the blocks face up and the switch "off"; the fuses being accessible.

The operating crank of the switch is so designed that

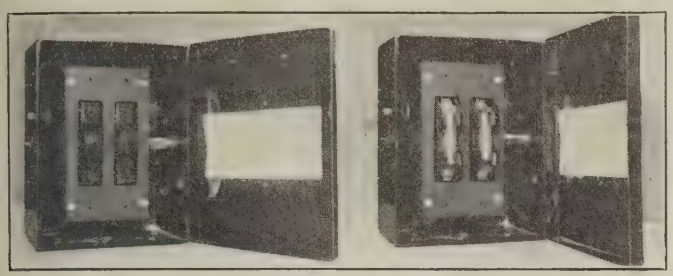


Fig. 1 Fig. 2

the door of the case can be opened only when the switch contacts are in either the full "on" or full "off" position The position of the crank and latch is shown in the "on" position in Fig. 3. Pushing these latch levers as shown in Fig. 4 releases the crank and opens the switch. With the door open the switch is inoperable from either posi-

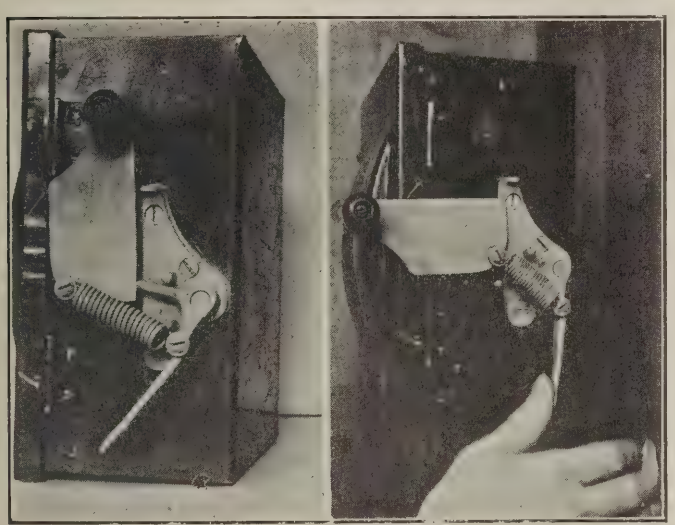


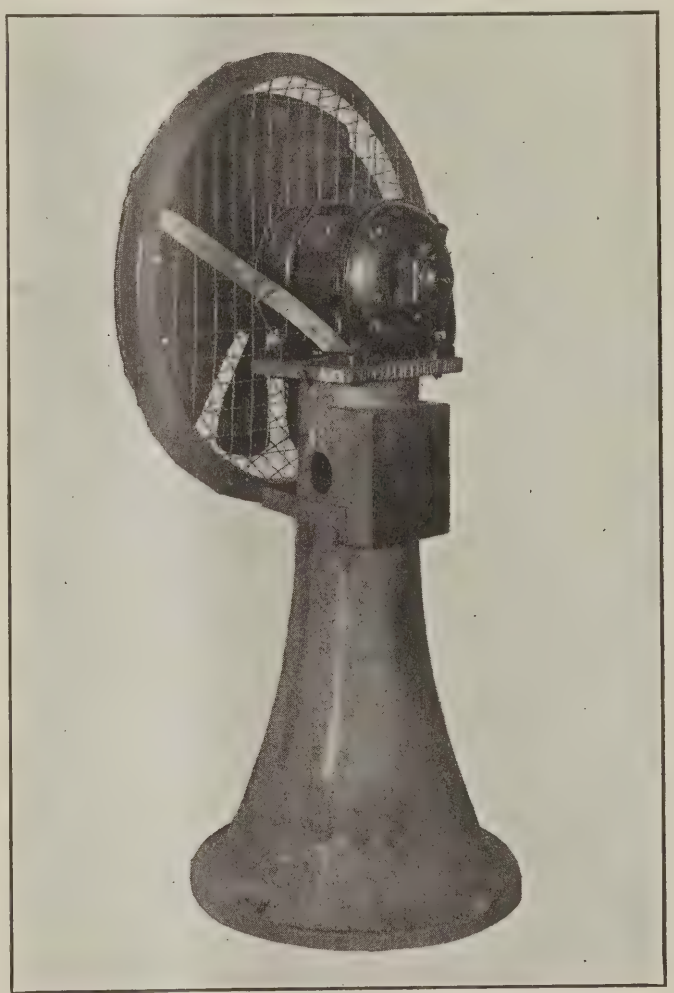
Fig. 3 Fig. 4

tion "off" and "on." Thus it is necessary to close the door to operate the switch. The coil spring between the latch and operating arm gives the quick break for the contacts and also causes a buffer action to eliminate jars. The switch cannot be left in partial contact, although the points may be touched momentarily.

New Man Cooler Fans

Workers in foundries, drop forge shops and other places where the heat is intensive will be interested in a new, high efficiency, man-cooler fan just developed by the Buffalo Forge Co., of Buffalo, N. Y. This unit is made in two sizes, the larger having a 36-in. diameter fan wheel while the smaller has a 30-in. wheel. The entire fan is of heavy construction, to insure against vibration; the screen enclosing the fan wheel is extra heavy, while the rim itself is made of 2¼ x 2¼ angle iron. The unit, however, can be moved easily from place to place.

This cooler, as shown here, consists of but three essential parts—the fan wheel, a direct connected motor and the pedestal. The wheel is composed of ten blades so designed that the air is delivered in a concentrated solid stream. This factor of air delivery is important here in order that the best cooling efficiencies at the lowest expenditure of power may be had. A direct connected motor placed directly back of the fan wheel supplies the motive power. The 36-in. man cooler fan is supplied with a 5 hp. motor, while the smaller fan is equipped with a 3 hp. unit. The speed for both fans is 900 r.p.m. The



Large Capacity Man-Cooler Fan

pedestal is a heavy casting; four bosses are provided in the base for foundation bolts in case the unit is maintained in a permanent location.

Because of the concentration of air obtained with this unit, the carrying power is great. It is claimed that men supplied with the cooling blast receive actual physical benefits which enable them to perform more work in the same time and decrease labor turnover. The motors furnished are large enough for continuous operation under the most severe conditions.

The watts input are 2,280 for the 36-in. fan and 1,340 for the 30-in. fan. The larger fan delivers 15,000 cubic feet of air per minute while the smaller one has just one-half this capacity.

General News Section

The Morse Engineering Co., St. Louis, Mo., have just been appointed exclusive territorial selling agents for The Ramsey Chain Co., general offices and works Albany, N. Y.

The Gibb Instrument Co., Bay City, Michigan, manufacturers of electric welding equipment, announce the appointment of D. A. Clements to represent them in Missouri and southern Illinois, with headquarters at 4167 Washington avenue, St. Louis, Mo.

The Missouri-Kansas-Texas is offering its employees an opportunity to purchase adjustment mortgage five per cent bonds of the road at 56 per cent of the par value. The company will buy the bonds on the open market and will sell them to the employees on a semi-monthly payment plan.

The Strom Ball Bearing Mfg. Co. announce the opening of the Strom Distributing Station at 2322 South Michigan avenue, Chicago, for the convenience of automobile and truck dealers, fleet owners, service stations, repair shops, and car owners. A complete stock of Strom ball bearings for replacements is available.

At Willow Grove Park, Philadelphia, Pa., on Sunday evening, July 27, a passenger train of the Philadelphia & Reading struck an automobile on a crossing and, besides wrecking the automobile and killing three of its occupants, was itself wrecked, the locomotive being overturned and the engineman being fatally injured. Five other persons were injured.

Ten persons were killed and the same number were injured when a bus carrying 26 persons, mostly children, was driven in front of a New York Central passenger train at Oak Harbor, Ohio, on July 23. The driver halted for an east-bound passenger train, according to witnesses, and started before the train had fully cleared the crossing, and as the bus passed behind the east-bound train it was struck by one moving west.

The double track electrification work on the Long Island Railroad between Jamaica and Babylon is being actively pushed. The erection of the six substations at Laurelton, Lynbrook, Freeport, Wantagh, Amityville and Babylon is scheduled to be completed by January 1, 1925. Equipment for the buildings is already being manufactured and the installation of this apparatus should begin in October and be finished by May 1, 1925, under the contract.

The Packard Electric Company, Warren, Ohio, announces the opening of a branch office at Atlanta, Ga., under the management of S. A. Redding. Mr. Redding recently joined the Packard Company, having been engaged for the past five years in consulting and construction engineering work in Rio de Janeiro, Brazil. Prior to his going to Brazil, Mr. Redding had many years experience as an electrical engineer with the Georgia Railway & Electric Company and the Georgia Railway & Power Company. The address of the Atlanta office will be 624-625 Healey Building.

Electric lights are required in the marker and classification lamps of locomotives in Canada by an order recently issued by the Board of Railway Commissioners. The order applies to all new engines that have electric light installations, and to all locomotives after December 31, 1925. This order is made on the basis of a hearing held last February, in which the brotherhoods claimed that oil lamps were not reliable and usually were not well maintained.

The superpower system of interconnected steam and hydro-electric generating plants that will serve all of the central, west and south of Germany is rapidly developing in that country as the result of high cost and shortage of coal. Tremendous deposits of lignite, a brown coal half way between peat and true coal, occur in the Rhenish Westphalian districts and Brandenburg and Saxony. Modern long distance transmission has made it possible to build generating plants at the lignite mines and carry the electric current to the points of demand. Forty per cent of all electricity developed in Germany is derived from lignite which is being used at the rate of 150,000,000 tons per year.

Railroad Wages Lead Other Industries

Railroad wages continue to lead those of manufacturing industries, according to the National Industrial Conference Board, New York City, which has recently investigated the trends of wages, hours and employment of railway labor as a whole from the 1914 period to the end of the first quarter of this year. In the first quarter of 1924, the average hourly earnings of all railroad wage earners were 60 cents, which is 136 per cent greater than the hourly earnings in 1914, and 10 cents below the highest peak of 1920. The purchasing power of the weekly earnings of these employees in the first quarter of 1924 was 30 per cent greater than in 1914, showing a slight increase since the second half of 1923. This condition is due to a slight increase in earnings and a slight decrease in the cost of living.

These figures are based on the average number of wage earners on those railroads whose annual revenues total one million dollars a year or over. During the first quarter of 1924, the number of wage earners stood at 1,249,873.

The board made a comparison between the trends of wages for skilled labor in foundries and machine shops and that of skilled shop labor on the railroads. In 1914, the average hourly earnings of both were nearly equal, but by 1920 the railroad group had advanced far ahead. In the first quarter of 1924 the earnings of skilled labor in foundries and machine shops were 108 per cent greater

than in 1914, but the railroad skilled shop labor at the end of last year were earning 142 per cent above the 1914 to 1915 level and advanced still further to 72.2 cents per hour in the first quarter of this year. The board's report discusses in detail the rates of wages of railroad workers in relation to their different classes of employment and in relation to the cost of living. Incidentally, it shows the hourly earnings of unskilled railroad workers were 130 per cent greater than at the end of the first quarter of 1924 than in 1914. It shows also that practically all increases and reductions in railroad wages since the termination of federal control were based on the rulings established by the United States Railroad Administration, and that the wages of the train and engine service employees, therefore, have never risen relatively so high as the wages of other classes of railroad labor.

In general, the board states that railroad labor as a whole and two of its principal sub-divisions—skilled shop and unskilled labor—were materially better off early in 1924 than in 1914. It is also shown that the average working week per employee was considerably shorter and the purchasing power of weekly earnings substantially greater. The position of the train and engine service employees, however, was not so advantageous as that of other classes of railroad labor or of railroad labor regarded as a whole.

Rock Island to Hold Tournament

The Chicago, Rock Island & Pacific will hold its first anniversary tournament in Chicago on October 11, incident to the 72nd birthday of the railroad. The tournament will consist of various athletic, musical and other events participated in by Rock Island employees representing the first and second districts. Employees eligible to participate in the tournament are to be chosen by elimination contests or trials on the various divisions of the two districts, the finals to be played by the representatives of the two districts at Chicago on October 11. To be eligible for entry in any of these events it is necessary that the applicant be an employee of the road and have been in the service for six months or more on October 10.

The events will include baseball, tennis, bowling, soccer, football, swimming, relay races, track and field events, tug of war, horseshoe pitching and checker contests. In the musical events there will be a contest between the best brass bands of each district and between the best orchestras of each district. In the case of events where teams or groups are contesting silver cups will be awarded as prizes to the winners. A supremacy banner will be given the district credited with the highest score of the tournament. The cups and supremacy banner will remain in the possession of the winners until the 1925 tournament. The winning of the cup or the supremacy banner for three consecutive years will entitle the team or groups winning in the same to retain them permanently. In addition to the supremacy banner, a division banner also will be awarded to the division with representatives who score the highest number of points in the tournament. The division banner will remain in permanent possession of the division winning it each year. Gold, silver and bronze medals will be awarded to successful contestants in the individual games.

Swedish Railways Changing Motive Power

A desire to utilize the country's abundant supply of "white coal," and keen competition of automobiles on the short-haul passenger and freight traffic, are two reasons for the increasing use of gasoline motors and the electrification of the Swedish railway system. Th "white coal" supply is preferred to fuel which can only be imported at great cost and is changing the great trunk lines of Sweden from steam railways to electric lines; while the result of the automobile competition has caused increased use of gasoline motors, particularly Diesel motors, and the shorter local passenger lines, mostly privately-owned, are now rapidly being transformed into a motorized train service. At the present time there are about fifteen of these trains in operation on the Swedish lines. From five to ten cars are now under construction, and plans are under way for an increase in the number of motorized trains—some for lines partly motorized and others for lines now using steam power exclusively.

The motor train is far more economical to operate on short lines, since only one operator is required; it also permits better service than a steam train. The Diesel operated trains have even competed successfully with both passenger bus lines and motor truck freight service in various sections of the country, and have apparently become an established part of the Swedish transportation system. It is thought that motor-train service will gradually displace the steam-driven train on the short or feeder lines, in the same measure as electric power is rapidly displacing steam on the trunk lines.

Personals

Edwin B. DeVilbiss, at one time electrical engineer of the Northwest System of the Pennsylvania, was recently promoted to the position of superintendent of motive power of the Central Pennsylvania Division eastern region of the Pennsylvania with headquarters at Williamsport, Pa. Mr. DeVilbiss was born September 13, 1884 at Fort Wayne, Ind., and was graduated from Purdue University in 1908. He entered the railway service on July 1 of the same year as special apprentice of the Pennsylvania in the Fort Wayne Shops and in January, 1911 he was promoted to motive power inspector. On April 1, 1912, he became electrical engineer of the Northwest System and on June 1, 1915 he was appointed assistant engineer of motive power on the Central system. He was appointed assistant engineer of motive power in the office of the general superintendent of motive power on October 15, 1917 and on March 1, 1920, Mr. DeVilbiss was promoted to superintendent of motive power of the Eastern Ohio division, with headquarters at Pittsburgh, Pa. A

E. B. De Vilbiss

year later he became master mechanic of the eastern division with headquarters at Canton, Ohio, the position be held at the time of his recent promotion to superintendent of motive power.

H. B. Clark, formerly an electrical engineer with the N. Y., N. H. & H. Ry., has taken the position of electrical designing engineer with the Solvay Process Company, Solvay, N. Y.

W. J. Emig has been recently appointed carbon product engineer connected with the railway sales division of the National Carbon Company, Inc., of Cleveland, Ohio. Mr. Emig was born at Buffalo, N. Y., August 30, 1886, and entered the employ of the Pennsylvania Railroad as car lighting electrician in December, 1911. In August, 1916, he was car lighting electrician for the Pullman Company. In August of 1920 he was appointed assistant foreman in charge of repairs to commercial electrical vehicles and from September, 1920, to August, 1923, he was connected with the Edison Storage Battery Company on sales and service work, at which time he was appointed a member of the National Carbon organization.

W. J. Emig

Trade Publications

Electric Machinery Manufacturing Company, Minneapolis, Minn., in its bulletin No. 833 illustrates and describes the E-M Junior synchronous motors for direct current connection to small compressors.

Electrical History—"Forty Years Ago," is the title of a 21-page booklet illustrated with pen and ink sketches, published by the Westinghouse Electric & Manufacturing Company. The booklet describes briefly electrical progress which has been made during the past 40 years and the relation of the Westinghouse Company to this progress.

Howell Electric Motors Company, Howell, Mich., has recently issued its new catalog showing exploded views of the Howell red band motors and explaining the construction details of these motors. A report from the Electrical Testing Laboratories is included in the booklet showing the result of high voltage test of insulated wire used in the manufacture of the Howell motors.

The Western Electric Company, New York, has recently issued a 40-page manual on commercial and industrial lighting. Among the subjects treated are the selection of lighting systems, types of lighting, the selection of fixtures, floodlighting and special lighting. Various kinds of lighting fixtures are illustrated and described and a number of plans are given on how to plan various lighting installments.

National Carbon Company, Inc., Cleveland, Ohio, has recently issued its new carbon brush catalog. As it is being distributed, the book contains 46 pages, but it is of the loose-leaf type of construction to allow for changes and additions which may be made from time to time. The catalog contains many illustrations of carbon brushes, diagrams of details and many useful tables.

The Superheater Company of New York and Chicago have just issued a second edition of its Instruction Book covering installation, operation and maintenance for Model 496 Superheated Steam Pyrometers. The book is intended primarily to give instructions covering the application of the pyrometer to superheater locomotives. A pyrometer test set is described and inspection of the pyrometer and tests of various parts with and without the test set are given. An added feature of this description of the book is the order list covering pyrometer parts in the back of the book. A copy of this book will be gladly sent to anyone mentioning this publication.

A text book on power transmission, and silent chain transmission in particular, has just been issed by the Ramsey Chain Co., Inc., Albany, N. Y. It is a 6 x 9, 48-page book, in two colors, illustrated and bound. It treats on the comparisons between the various methods of drives, leather and rubber belting, gearing, direct drives, and silent chain. It covers the transmission problems in the following fields: Machine tool, punch presses, shears, wood-working machinery, fans and blowers, mixing machinery, grain elevators and flour mills, pumps and compressors, etc. It has complete engineering information and data for laying out silent chain drives.

Albert & J. M. Anderson Manufacturing Company, Boston, Mass., has just issued its bulletin No. 37 illustrating and describing Anderson automatic time switches. The bulletin contains 48 pages and covers practically every condition for which automatic time switch devices are used. The clocks used with these switches are unique in many respects. Among other features is the Sunday or holiday cut out attachment and the season changing devices whereby the variation in the time at which the clock operates the switch morning and night is in accordance with the season of the year. The time switches are made in a number of types for different purposes and are electrically wound or hand wound as desired.

The Westinghouse Electric and Manufacturing Company has recently published a new booklet known as Folder 4532-A, dealing with Westinghouse Fabrics and Papers for insulating purposes. All the forms of treated and untreated fabrics, papers, sleeving, tapes, cord and thread manufactured by the company are fully described in the booklet and their principal applications given. For the purpose of easy reference, tables have been included setting forth in tabulated form the thickness, width, approximate weight, and size of the various materials described. For the treated fabrics and for the untreated fabrics and papers, approximate breakdown voltages have been given for each material under these classifications. The materials described in this folder are those used in the manufacture of Westinghouse electrical apparatus and made available to the general trade. The booklet is of interest to all users of insulating material in any of its various forms.

Railway Electrical Engineer

Volume 15 SEPTEMBER, 1924 No. 9

What Are Your Batteries Doing?

To say that batteries will give satisfactory performance if they are properly cared for is a platitude. Giving them the attention they deserve requires systematic supervision. To apply systematic supervision to railroad conditions is often difficult, but it is not impossible. The method used must be sufficiently flexible to include all of the various conditions under which the batteries are used and it must at the same time be simple if it is to be effective.

A simple and effective method of keeping a record of storage battery conditions developed on the Soo Line is described elsewhere in this issue. A card file holds the complete history of each battery so that it can be found easily when wanted and the card file is made effective by a bulletin board which keeps the condition of all batteries on the road constantly before the eyes of the supervisor. The board is a form of condensed index, posted on a bulletin board and kept up-to-date from the work reports turned in each day by the foremen. The scheme is simple, usable and effective. The size of the board required might limit its application on very large roads, but it is also possible that a modification of the method could be made in such cases. Certainly the method merits the attention of all who have need of an easy system for keeping an accurate record of battery conditions.

The Fifteenth Annual Convention

The convention of the Association of Railway Electrical Engineers in Chicago next month will be the fifteenth annual get-together meeting. On one or two occasions it has been advisable to omit the convention due to unusual economic conditions, but these omissions have inevitably been followed by a larger and, in every respect, a more successful meeting in the following year.

It has been apparent for several years that different arrangements would have to be made properly to accommodate the increasing number of electrical supply manufacturers who exhibit their products during the convention. In the past both the exhibits and the convention meeting have been held on the same floor of the hotel, but this year the entire 19th floor has been given over to the exhibitors while the meetings will be held in another part of the building. As with the majority of the A. R. E. E. conventions, this one will be at the LaSalle Hotel in Chicago and the sessions will be held from October 21 to 24, inclusive. It is more than probable that the exhibits will be ready for inspection during the evening of October 20, although the first convention session will not be held until the following morning.

The indications are that the committees will break all previous records in the scope and character of their reports. If you are at all interested in knowing what the latest electrical developments are, by all means be on hand when the gavel falls. You may think you are doing things pretty well on your own road, but it is not impossible that you may get quite a surprise when you find out someone else has rendered your methods obsolete. There's nothing more true than the old motto, "Live and Learn." It is far better to be jolted out of your complacency than to go along missing the advantages of doing the thing the "better way" simply because you never heard of it. Don't overlook any benefits you ought to enjoy—in short, make it your business to be at the convention!

Laying Out Work

Wiring and lighting layouts are usually made in the field; someone goes to the place where the work is to be done, observes requirements, takes measurements, plans the layout and writes up a complete bill of material. Sometimes the layout is made at headquarters, the bill of material being made up from the blueprint plan and elevation of the building to be wired. Frequently this second method causes trouble. The blueprint does not show a variety of local conditions which necessitate changes in the wiring and the result is that too much time must be spent doing the work, more material must be provided, or some compromise must be made in good workmanship.

Sending a man out from headquarters to lay out the work does away with such difficulties, but electrical work now has many ramifications and there are many small jobs to be done at widely separated places. The electrical engineer, or his first assistant, once did all of the layout work, but on the larger roads that is no longer possible. A man located permanently in the district plans the work, or it is done by the construction foreman who happens to be near the place when it becomes necessary to lay out the work and prepare a bill of material.

Wiring and lighting practices throughout the country for all kinds of service have reached a high state of development. It can be said of the railroads, and to their credit, that they use the best of these methods. Railroad conditions require rugged material that is dependable and that requires little maintenance. This fact is sometimes overstressed to the point where the railroad man thinks he must have something special. Wiring devices

are now available, however, to suit the most exacting, and the modern tendency is to make railroad lighting conform closely with the rather more highly standardized industrial practice. Light is becoming the paramount issue and wiring and lighting devices are used which will provide lighting to meet good standards of illumination.

The present need of the railroads therefore is to establish more highly standardized methods for wiring and lighting buildings and yards. Some roads have already done this and have profited by the results. Good light is provided—making it possible to speed up the work and do it more efficiently—and lighting installation work has been greatly simplified. The local man, even though he is not an electrical engineer, when he is given a code and a list of standard material, can with his knowledge of local conditions make out a complete bill of material for any one of the small installations that must be made from time to time.

Using Lighting Facilities

In an editorial in another column entitled "Laying Out Work," the statement is made that railroad managements have come to the realization that good light is essential to good shop work. At one time a few electric lights which would serve as markers to keep men from falling in the pits in a roundhouse, augmented by smoking torches, was considered sufficient. Now something that can be classed as illumination is demanded and this demand is being backed up with justification by the lighting requirements of a number of state industrial commissions.

Given a good lighting system it is necessary to maintain it and this part of the problem is not so often given sufficient consideration.

The value of a reflector lies in its ability to collect the light from a lamp and distribute it properly over a useful plane or working area. This value is easily and rapidly lost through the accumulation of dirt. Such an accumulation also shortens the life of a reflector as the dirt collects corrosive elements. Obviously it is necessary to keep reflectors clean. Strange as it may seem, however, there are thousands of high grade reflectors in shops and yards literally rotting away with dirt and rust and not performing the service for which they were purchased. There are just two remedies for the situation, both of which should be applied. The lighting units should be made accessible and the users of the light should be educated to the value of keeping the reflectors clean. Cleaning reflectors may be made easy by mounting the unit in such a way that it can be lowered for cleaning or for making lamp renewals. If this feature is not included, care should be taken to mount the lamps so that they can be reached easily with the aid of a ladder, from a crane or otherwise. A lighting unit placed in an inaccessible position soon becomes in reality a small heating element which uses current, but gives very little light.

The lighting engineers on some roads have accomplished much in the way of education by preparing brief instruction bulletins covering the use of lamps and reflectors; these are sent to all points on the road with an edict from the management. Asking a man to use the tools which have been furnished to make his work easy would appear unnecessary, but apparently the value of good light is rather generally overlooked and missionary work is still needed.

New Books

Arc Welding Handbook. By C. J. Holslag, 250 pages, illustrations, diagrams, 5 in. by 7½ in., bound in imitation leather, semi-flexible covers. Published by the McGraw-Hill Book Company, New York City. Price $2.00.

The book is a practical manual for instruction in arc welding. Each detail of every type of arc welding is fully explained in such simple language as to permit no room for doubt as to just what the writer intended. Not only is the book of value to the beginner, but it is useful to the welding supervisor as well. Furthermore, the arrangement of the subject matter is such that the work may be readily adapted for use as a text book in schools and colleges. In fact, the book was obviously prepared with this thought in mind for at the end of each of its 25 chapters, a number of questions are given covering the subject matter in the chapter immediately preceding.

Handbook of Direct Currents. By K. C. Graham, 164 pages, 102 illustrations, 5 in. by 7¼ in. Bound in cloth. Published by Simmons-Boardman Publishing Company, New York City. Price $2.

Many books have been written on direct currents but it is doubtful if any has ever before approached the subject in the same manner in which the author has in this little volume. The book is prepared to meet the need of the novice in electrical work, the beginner who requires his information in easy steps, which are fully explained in simple language and by sketches which are readily understood. The material has been arranged in a logical manner, beginning with the most elementary principles and proceeding by easy steps to the more technical phases of the subject.

While the book is entirely suitable for the use of anyone desiring to acquire a knowledge of the underlying principles of direct current, it is especially well adapted to the use of men engaged in car lighting departments of steam railroads. The author of the book was at one time employed in this branch of work and understands the need of the men in this field for a knowledge of the basic theory which is so valuable to the successful development of the railroad electrician. As may be appreciated from the size of the book, it contains no superfluous matter, and yet a careful inspection fails to show that anything important to the education of the reader has been left out. In short, the book fills a long felt want for men who have not had the opportunity for class instruction, but who are desirous of advancing themselves by gaining a knowledge of the principles which they are applying in their daily work.

Developments in Power Station Design. By Edwin Austin, 271 pages, illustrations and diagrams, 8 in. by 11 in. Bound in cloth. Published by D. Van Nostrand Co., New York City. Price $9.00.

Present interest in more efficient utilization of national power resources is the reason for the publication of this book, which is based on a series of articles that appeared in "The Engineer" during 1921 and 1922. The author describes modern power-plant practise in Great Britain and elsewhere, paying particular attention to the devices and methods that promise great efficiency. The account is descriptive, rather than technical, and is intended primarily for those connected with large public electric plants. It is based on personal visits to power plants and on information obtained from specialists.

Keeping a Record of Storage Battery Conditions

Soo Line Has a Method Which Keeps This Information Posted in Readily Usable Form

THE method used for keeping car lighting battery records on Minneapolis, St. Paul & Sault Ste. Marie is one which keeps the condition of all batteries before the eyes of the supervisor, with the result that both battery failures and repair work are minimized.

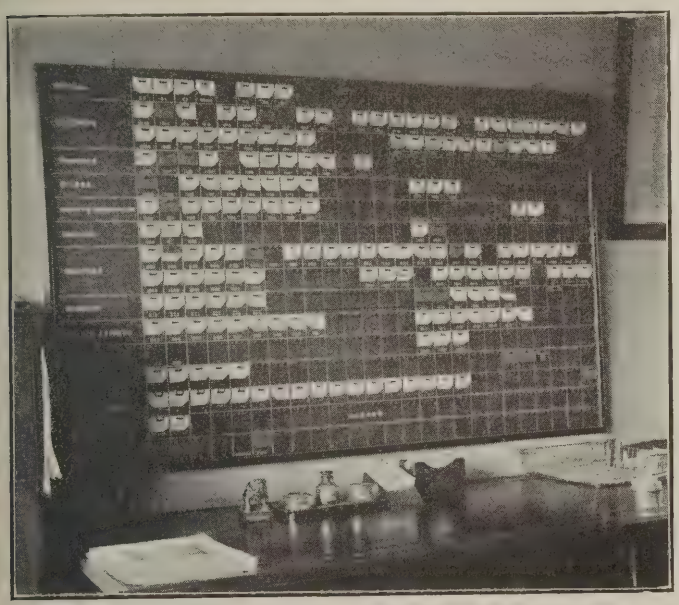


Fig. 1.—Bulletin Board Which Shows Location and Condition of All Batteries on the Road

It involves the use of a bulletin board, a card index and a pocket note book.

The board, shown in Fig. 1, is hung on the wall directly in front of the supervisor's desk. It is in effect a sort of cross index which shows at a glance the location of each battery on the system, shows which batteries have been in service without overhauling for more than a year and shows which batteries are in such a condition that they will not stand another cleaning. It also shows which cars are in the shop and which cars are electric lighted.

The board is a black wooden bulletin board about 3 ft. high and 5 ft. long. Its surface is divided into squares measuring 2¼ in. across. Each square bears a car number and each horizontal row of squares includes one kind of cars. The horizontal rows are labelled on the left of the board as follows: Official cars, sleepers, tourists, diners, buffet and observation cars, parlor cars, coaches, mail and express cars, mail cars, battery house, shops and trucks. The horizontal row, including cars in shops, is subdivided, St. Paul and Chicago. The last row marked "trucks" is used only for batteries in truck and tractor service. If there are more of one kind of car than can be listed in a single line, as in the case of coaches and sleepers, enough lines to include all cars are included in the label or title at the left.

Two small screw hooks are screwed into each square near the top of the square and about one-half inch apart. A white tag bearing the number of the battery on a certain car is hung on the hooks over the proper square. The tag covers all of the square except for about one-half inch of the bottom where the car number is stencilled in white. In this way the number of each car and the number of the battery being used in the car are shown together. A letter on each tag indicates the make of the battery. If a car is not electrically lighted, its square bears only the car number and no tag is hung on the hooks.

After a battery has been out of the shop and in service for a year a red tag is hung under the battery card to indicate this fact. This red tag is left on until the battery has been overhauled, but it does not mean that the battery is in immediate need of overhauling.

A yellow tag hung under the battery tag indicates that the battery has had its last cleaning and that it must be

Form 1397

M. ST. P. & S. STE. M. RY. CO.

DESCRIPTION AND RECORD OF BATTERY

Requisition No._____ Inv. No._____ Price _____

NO._____ TYPE_____ SIZE OF PLATE_____ "H I +_____ "W +_____ "T ASSEMBLED IN_____ CELL TRAY R'B JAR L'D TANK

NEW IN SERVICE_____ 191_____ RATED CAPACITY_____ AMP. HR'S ACTUAL CAPACITY_____ AMP. HR'S.

DATE CLEANED	PO'S PLATES		HEIGHT SEDIMENT	CONDITION ELEMENTS	CAPACITY TEST	GENERAL REMARKS	DATE	APPLIED	LOCATION		REMOVED	
	BKL'D	AV'G HI						CAR	AMP.	DATE	CAR	

Fig. 2.—Front of Battery Record Card

BATTERY MATERIAL CARD

DATE	TRAY WOOD	LEAD TANKS		RUBBER						ELEMENT		ACID	CONNECTORS				REMARKS
		NEW	REP'D	JARS	SEPT'R	SHEET	COVER	BUSH'G	TUBING	Positive	Negative		LONG	SHORT	HAND	WIRE	

Fig. 3.—Back of Battery Record Card

equipped with new positive plates the next time it is brought into the shop. When a battery is fitted with new positives, it is given a new number.

When a battery on the road or in the yards is in immediate need of attention, a ⊥-shaped red tag is placed

Battery	New	Dates Cleaned										Location
		1	2	3	4	5	6	7	8	9	10	
1	8-20	✓	4-22	✓	5-24							984
2	8-20	✓	3-22	✓	4-24							1510
3	8-20	✓	✓	5-23								2016
4	8-20	✓	✓	5-23								412
5	8-20	11-21	✓	12-23								990
6	8-20	12-21	✓	11-23								House
7	8-20	✓	✓	2-23								1515
8	8-20	✓	4-22	✓								2110
9	8-20	✓	✓	8-23								757
10	8-20	12-21	✓	11-23								House

Fig. 4.—A Sheet Taken from the Pocket Size Loose Leaf Master Record

on the hooks so that the tag stands upright and points to the battery needing attention, rather than being suspended below the hooks. This tag is kept in place until the battery has been repaired.

In order that the red or yellow tags may be more readily

New Form 2390 (Old 1398)

MINNEAPOLIS, ST PAUL & SAULT SAINTE MARIE RY. CO.

CAR LIGHTING PERFORMANCE REPORT.

CAR_____ TRAIN _____

PLACE_____ DATE_____

APPARATUS WORKING_____ LIGHTS FAIL_____

SP. GR._____ HEIGHT OF ACID_____

VOLTS BATTERY_____ VOLTS LIGHTS_____

BATTERY CHARGED_____ HOURS_____ AMPS.

BELT_____ TRAIN CONN._____ FUSES _____

LAMPS MISSING _____

COND. OF EQ'PT ON DEPARTURE_____

CAUSE OF FAILURE AND ACTION TAKEN

SIGNED_____ ELECTRICIAN.

MAIL ORIGINAL REPORT TO ELECT. INSP.,
SAINT PAUL.
PLACE BOOK IN LOCKER

Fig. 5.—Report Blank Filled Out by Electrician Each Time Work Is Done on Lighting Equipment in a Car

observed one of lower corners of the white tags is clipped off. The tags used for this purpose are old style baggage destination tags.

One of the cards from the card file is shown in Figs. 2 and 3. The card is 8¼ in. wide and 5 in. high. The front of the card, shown in Fig. 2, includes a description of the battery and a chronological record of its performance and condition. The back of the card, shown in Fig. 3, lists the amount and kind of parts and material required by the battery throughout its life.

One sheet from the loose-leaf master record carried by the supervisor is shown in Fig. 4. This sheet is 6¾ in. wide by 3¾ in. high and includes only the battery number, the date when the battery was placed in service, the several cleaning dates and the location of the battery. If the battery is in a car, this is shown by the car number and, if the battery is in the shop, it is designated by the word "house" meaning battery house.

A sample of the report blank filled out by the car lighting electrician is shown in Fig. 5. A book of these blanks is kept in the locker of each car. Every other page in the book is perforated and the pages which are not perforated

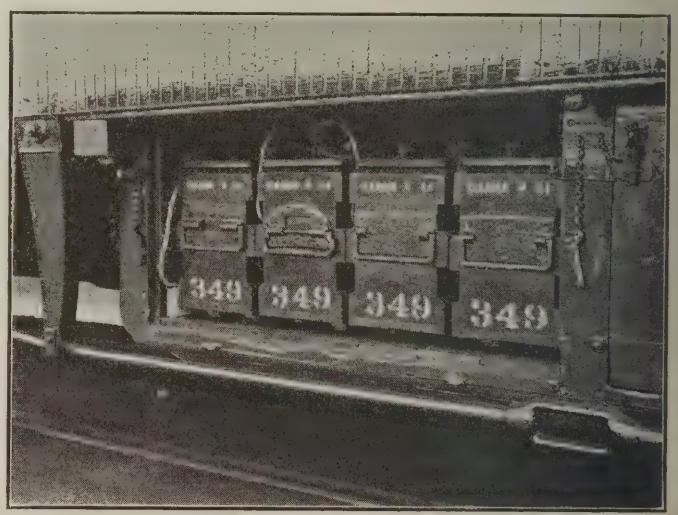


Fig. 6.—Batteries Are Stenciled Plainly With White Paint Showing Car Number and Last Cleaning Date

have a carbon coated back. The reports are thus made out in duplicate and the duplicate report is sent to the supervisor.

A number of the reports are received by the supervisor every day from each terminal on the road. Such data as is needed for the card index or master record is transferred to these records and if the report bears information which changes the conditions as shown on the board, the changes are made.

When a report comes in stating that the battery on car No. 988 must be cleaned, a ⊥-shaped tag is placed on the hooks in square No. 988 on the bulletin board. An order is then issued to send the car to the shop where the battery which needs cleaning is exchanged for another one. After the battery has been changed, the ⊥-shaped red tag and the white battery tag are removed and a white tag bearing the number of the newly applied battery is hung over the car number square.

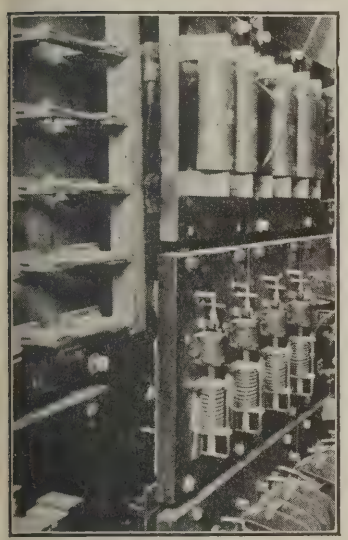
If a complaint is made that the lights are bad on car No. 796 and the board shows a yellow tag on square 796, meaning a run-out battery, an electrician is instructed to test the equipment immediately and if the equipment is found to be in good condition, the battery is removed from the car.

When the record system was first put into effect, an effort was made to reduce the number of red cards to the lowest number possible, or, in other words, to keep ahead on the amount of work to be done and have as many

newly cleaned batteries in service as possible. This effort was later changed and now a large number of red cards are looked upon as a credit for it means long periods between cleanings and correspondingly fewer cleaning periods.

To assist battery maintenance at terminals and in yards, each battery is stencilled plainly as shown in Fig. 6. The battery number is shown on the bottom of the battery tray and the date of the last cleaning or the date when the battery was first placed in service is shown at the top. If the battery is nearly worn out, "run-out" is stencilled on with the cleaning date.

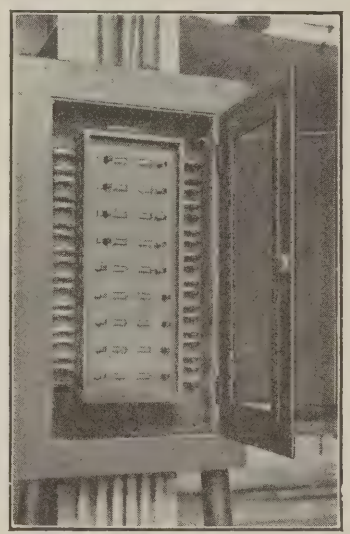
The record system was developed by S. D. Dimond, chief electrician.



Electric Fuses, Their Use and Abuse

Why Circuits and Equipment Often Lack the Actual Protection Which They Appear to Have

By Louis D. Moore
Electrical Engineer, Missouri Pacific R. R.



OF all electrical devices the fuse is probably the most universally used, its only possible rival being the incandescent lamp. Because its purpose is very generally misunderstood it is also one of the most abused of the common electrical devices.

The fuse is the electrical equivalent of the safety valve and is strictly a protective device. It is an intentionally weakened spot in the wiring system, designed to fuse or melt from overheating due to excessive current in the circuit, thus opening the circuit before this excess current causes damage to the wiring or apparatus to be protected.

Fuses, in their earliest form, consisted merely of pieces of copper wire, of a size considerably smaller than the circuit wires, inserted in the circuit so that they would fuse before the circuit wire became overheated should an overload occur. As the melting point of copper is comparatively high (1985 deg. F.) these fuses were soon recognized as hazardous, due to the high temperature attained before melting, and the flame and molten metal resulting when the wire actually melted. The next step was the use of lead alloy, which had the advantage of melting at a much lower temperature than copper. However, as this "fuse wire" was used by simply wrapping the ends around the binding posts of the fuse block, or, later, by means of copper terminals attached to the ends of the fuse wires, the hazard of flame and molten metal still remained. Later these fuse "links" were enclosed in tubes of more or less non-inflammable materials, which were a protection on moderate overloads, but served to compress the gases liberated by the sudden melting of the fuse wire due to short circuits, resulting often in severe explosions of the casing.

The modern fuse consists, essentially, of a strip of metal having a low melting point (usually pure zinc) enclosed in a fiber or porcelain casing. The width and thickness of this strip, or element, as it is called, are so dimensioned that the strip will melt at a very definite predetermined current value. This melting is accompanied by a puff of vaporized metal from which is derived the popular term "blowing a fuse."

There are a number of different types of fuses, including those for use in high voltage circuits, those for telegraph and telephone protection, as well as those used for the protection of lighting and motor circuits of moderate voltages. There are several obsolete types of the latter. There are at present, however, only three approved types for low voltage interior wiring, these having been standardized by the National Board of Fire Underwriters, in conjunction with the fuse manufacturers.

One of these types is the Edison fuse plug, or "plug fuse," as it is often called. The other two types are popularly known as "cartridge fuses," although more technically known as "National Electric Code Standard," or simply "New Code" fuses. These cartridge fuses are made in the familiar ferrule and knife blade types, and for use on voltages up to and including 2500 volts. They may also be obtained in the "renewable" type and in the non-renewable or "one-time" type.

Fuse plugs are made in capacities of from 3 amperes to 30 amperes only, and are approved by the Board of Fire Underwriters for use on 125 volts and lower only. They should not be used on circuits of higher voltage because the spacings are close and an arc, once started, may continue until the fuse block is destroyed. Until recently there was no way to readily distinguish fuse plugs of different capacities other than by looking at the rating as marked on the shell or tip. This was the cause of more or less confusion and abuse, resulting in many fuses of 20 to 30 amperes finding their way into branch cir-

cuits, whose carrying capacity is only 15 amperes maximum. However, with the advent of the 1923 Rules of the Board of Fire Underwriters, better known as the "National Electric Code," fuses of 15 amperes capacity and less must have a hexagonal shaped "window" in the top, while the higher capacities must have a round window. As soon as old stocks have been worked off this marking will be universal, and there should then be little excuse for over-fusing these circuits.

Cartridge fuses are made in capacities of from 1 to 1,000 amperes, and in order to save confusion the same size of casing is used for several capacities as follows:

	250 Volt		600 Volt	
	Length overall	Diameter casing	Length overall	Diameter casing
1 to 30 amperes	2 in.	½ in.	5 in.	¾ in.
35 to 60 amperes	3 in.	¾ in.	5½ in.	1 in.
65 to 100 amperes	5⅞ in.	1 in.	7⅞ in.	1¼ in.
110 to 200 amperes	7⅛ in.	1½ in.	9⅝ in.	1¾ in.
225 to 400 amperes	8⅝ in.	2 in.	11⅝ in.	2½ in.
450 to 600 amperes	10⅜ in.	2½ in.	13⅜ in.	3 in.
650 to 800 amperes	11½ in.	3 in.	14½ in.	3½ in.
850 to 1,000 amperes	15⅝ in.	3½ in.	15⅝ in.	4 in.

Since the use of fuses is closely related to the matter of fire hazard their manufacture is supervised quite closely by the Underwriters' Laboratories, which are maintained by the National Board of Fire Underwriters. The Laboratories have a number of requirements for fuses which are rigidly enforced by them through the medium of their label service. This service is recognized by inspection departments throughout the country and unless the fuse bears the inscription "Underwriters Laboratories Inspected" or its abbreviation their use is not allowed.

In order to meet the requirements of the Laboratories, and thus obtain the right to use of the above inscription, fuses must meet the following conditions:

Must conform to dimensions prescribed by the Laboratories.

Must withstand heavy short circuits. Failure to do so would result in a great fire and life hazard, as the fuse would explode, belching fire and causing possible personal injury.

Must carry their rated currents, otherwise premature burnouts would occur, causing increased expense and inconvenience.

Must open the circuit promptly on overload, thus preventing damage to wiring and apparatus.

Must operate at low temperature, otherwise a fire hazard would be created.

Must carry *ten per cent overload* (that is, ten per cent over their rating) indefinitely, and must blow at 50 per cent above their ratings within the following time limits:

1 to 30 amperes	1 minute
31 to 60 amperes	2 minutes
61 to 100 amperes	4 minutes
101 to 200 amperes	6 minutes
201 to 400 amperes	12 minutes
401 to 600 amperes	15 minutes

As has been said, the fuse is a protective device. Its purpose is to heat and melt before the wiring which it protects heats sufficiently to damage the insulation thereon. The amount of heating which may be permitted in a wire depends largely upon the material with which it is insulated and upon its use. The National Electric Code, issued by the National Board of Fire Underwriters (and popularly known simply as "the Code") prescribes the amount of current which may be safely carried without overheating by wires used for building wiring. Hence, the capacity of fuses protecting such building wiring should not exceed the carrying capacity of such wire, as given in the National Electric Code. Greater fuse capacity may result in overheating the wire and damaging or destroying the insulation. This is particularly true of rubber insulation, which, although it may not be destroyed immediately, will become powdery under continued heating. It is for this reason, also, that proper capacity fuses should be installed wherever the size of the wire is decreased, unless the last fuse back on the larger wire is of small enough capacity to protect the smaller wire. For instance, if a No. 14 wire circuit were tapped directly to a 0000 feeder, which can safely carry over 200 amperes, a short circuit on the No. 14 wire could and would burn the wire in two without blowing fuses which would adequately protect the larger wire.

The wires used for winding electrical machinery and other power apparatus are usually not insulated with rubber, and the amount of heating they will stand safely has been determined by the manufacturers, and is usually much greater than allowable for building wiring. For this reason the rating of al electrical apparatus is required by the National Code to be shown on a name plate, as a guide to proper capacity fuses or other protective apparatus. Uusually motor fuses are rated at 10 per cent above the ampere rating of the motor, except that induction motors often have large fuses on the starting side of the starter as compared with the running fuses, in order to carry the large starting currents drawn by such motors. Most inspection bureaus prescribe the capacity of fuses which they consider proper for motors of various sizes and voltages, and these ratings should be followed.

As has been said, the fuse is intended for protection, but this fact seems to be lost sight of by many who should know better. Often the trouble is due to ignorance, as in the case of the lineman who said that "those were the best fuses he ever saw. He just *couldn't* blow them!" Sometimes, however, it is due to disinclination on the part of a maintenance electrician, as in the case of a maintenance man who deliberately overfused a small motor with the remark that he "guessed that would hold it." It did—until the armature burned out. Again, there is a combination of indolence on the part of the electrician and lack of support from his superior, who, in such cases, is usually not an electrical man. I once talked to a maintenance electrician about fusing a 12 ampere motor with 30 ampere fuses, and he told me of a condition of abuse of the machine which resulted in very frequent blowing of fuses. When asked why he didn't take the matter up with his superior he remarked, "Oh, he'd just laugh at me," which was true. A burnt out armature, however, was "just an accident" and not a matter for criticism.

While installing fuses of a higher rating than proper is bad enough, the practice of "doctoring" fuses is much worse. I have seen ten penny nails driven through 60 ampere fuse casings, No. 4 iron wire in the clips instead of 100 ampere fuses, No. 6 copper wire installed in a blown fuse cartridge of 100 amperes or less rating, fuse plugs filled with solder, to say nothing of pennies or small copper discs behind fuse plugs, two and three renewable fuse links in refillable fuses and arc lamp carbon in 30 ampere fuse clips. One fuse had been very expertly "doctored" so that the only evidence of what might be

inside the casing was that the ferrule had welded to the clip! These practices entirely eliminate the fuse as a protective device. The No. 6 copper wire, for instance, will only melt with a current around 600 amperes, yet it was installed instead of a fuse of 100 amperes or less! I do not know what the "fusing capacity" of the arc lamp carbon, or the pennies, or the No. 4 iron wire, is—it is sufficient that it is many times that of the proper fuse. Many electricians and others think they are being very moderate when they substitute one or two No. 14 copper wires for a fuse element of 30 amperes or less. Yet it requires 166 amperes to melt a wire of this size! And the circuit it "protects" is often of the same size wire as this "fuse."

Another more or less frequent practice is to wrap wire or car seals around the clips of New Code fuse blocks, and I received a very considerable "jolt" once when attempting to pull a fuse that had a strip of wire solder on the back of it, bridging the ferrules.

While the use of other than standard fuses or fuse materials should be avoided wherever possible, emergencies will arise when standard fuses are not available and operation must be maintained. In such cases the proper procedure is not to "load" the fuse so that it is practically impossible for it to blow, but to use as a substitute for the fuse a material that has a real protective value. A very convenient emergency fuse material is ordinary lamp cord. This is composed of a number of strands of No. 30 gage wire. Each No. 30 strand has a fusing capacity of about 10.25 amperes and by combining a number of such strands an emergency fuse of any capacity which is a multiple of ten may be obtained. Copper, iron and aluminum wires may also be used if the proper sizes are selected, although the old objection of high temperature necessary to melt such wires still exists, and they often blow with great violence. The following table of fusing currents of copper and iron wires is not only useful as a guide to emergency fusing, but also *shows the danger* of using the larger sizes of wire to bridge fuse clips of ordinary capacities:

Fusing Current for Copper and Iron Wire

B. & S. Gage	Amperes Copper	Amperes Iron	B. & S. Gage	Amperes Copper	Amperes Iron
7	520	...	26	20.6	6.22
8	450	...	27	17.7	5.36
9	320	...	28	14.7	4.45
10	335	101	29	12.5	3.79
11	280	86	*30	10.25	3.11
12	235	71.2	31	8.75	2.65
14	166	63.0	32	7.26	2.20
16	120	60	33	6.19	1.88
18	82.8	25.1	34	5.00	1.50
20	58.3	17.7	35	4.40	1.30
21	49.3	14.9	36	3.62	1.00
22	41.2	12.5	38	2.50	.77
23	34.5	10.9	39	2.00	.67
24	28.9	9.1	40	1.80	.50
25	24.6	7.46			

*No. 30 is the size of strands for lamp cord.

While the above methods are given to assist in emergency cases, they should be so used only, and *proper fuses installed as soon as obtainable.*

Finally, the matter of poor contact between fuses and their holders is a subject that deserves attention. When installing a wiring job all joints are thoroughly made mechanically and soldered in order to get good contact. Care is taken that all joints in switchboard and panelboard busses are thoroughly tight, that wires are making good contact under binding posts and all commutator and slipring leads are sweated to their respective collector devices. Yet it is surprising how often the matter of contact between fuses and their clips is overlooked. If a ferrule type fuse (60 ampere capacity and under) can be easily turned in its clips it is making poor contact and may heat sufficiently to blow the fuse or burn the fiber casing where it is attached to the ferrule. Cases have been known where improper milling of the jaws of knife-blade fuse holders caused excessive heating, destroying not only the fuse but heating up the bus bars. Such a case was that of a large installation of power distribution panels. The fuses were destroyed almost as fast as put in and the owner was at a loss as to the cause. Tests showed his motors were not overloaded and an investigation by the panel-board manufacturer failed to disclose the seat of the trouble. Finally outside engineers were called in and found that while the fuses were apparently tight in their clips, they were making contact only at the top of the jaw, where they had been pulled together. These jaws had been milled out slightly too much, with serious results.

Fuse clips which may have been all right originally often become bent out of shape, thus causing trouble, and for this reason everyone concerned with the use of fuses should watch the clips very closely. The same condition with respect to poor contact and heating exists with the larger fuses as with knife switches and the writer recently inspected some large switches on a switchboard which were heating so, due to poor contact, that the hand could not be kept on them. Burning of the fiber casing of the cartridge is a sure sign of heating due to poor contact. A fuse was recently examined while in service where a hole had been burned in the casing (near the ferrule) so that the fuse link could be seen intact and carrying current. The hole in the casing was entirely due to poor contact. Fuse contacts should be watched for signs of heating and immediate steps be taken to remedy the trouble when it first appears.

In conclusion, it should be remembered that the fuse is "electricity's safety valve" (to quote the slogan of one manufacturer), that its abuse may result in just as serious results as "tying down the safety valve," and that poor contact, rather than overload, is often responsible for frequent blowing of fuses.

P. & A.

A Trackless Gas-Electric Locomotive Used for Industrial Switching in Baltimore

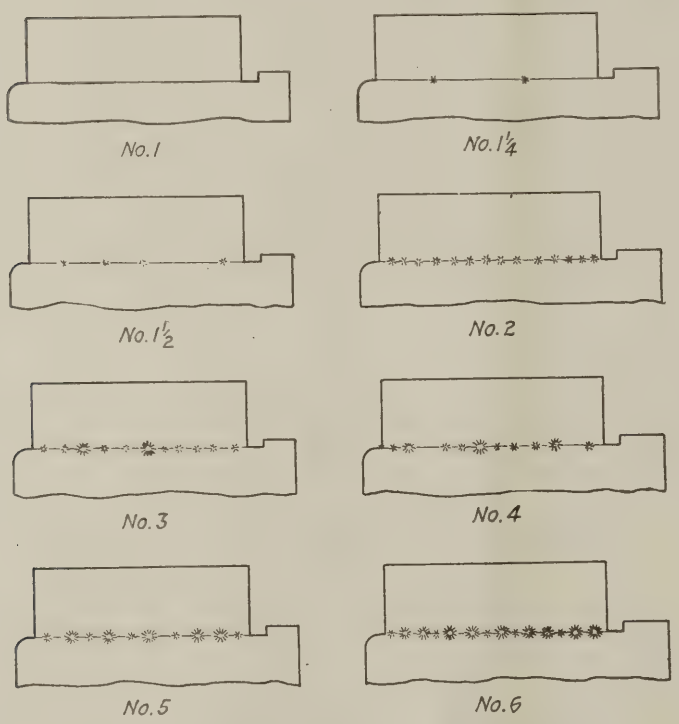
Some Causes of Sparking*

Nearly every fault about a machine whether it be mechanical or electrical, is manifested by sparking at the brushes. Consequently it is often a very difficult matter to diagnose a case of sparking correctly. We are giving below an outline of some of the most common causes of sparking and where possible have indicated an immediate remedy. The use of this outline will, in most cases, lead to a quick solution of any sparking trouble.

It is often desired, especially in plants where a large number of machines are used, to have some method of indicating the degree of sparking of any particular machine. In this article we have inserted a chart in which the degrees of sparking have been arranged in numerical order. For comparison and reference purposes this chart has proved very valuable.

1. Brushes off electrical neutral.—Shift to neutral by trial, or set on neutral by means of voltmeter.

2. Brushes spanning too many bars.—Trim down



Various Degrees of Generator and Motor Sparking

faces of brushes for short distance back from end or, if holders are clamp type, order thinner brushes.

3. Brush studs not parallel with the commutator bars.—Bend the brush studs or grind or shim under the bolts which fasten the studs to the yoke.

4. Incorrect brush spacing.—Check the spacing by counting the number of bars between studs or by placing a strip of paper around the commutator with divisions marked off equal to the number of studs, and correct spacing by rotating the brush studs or the brush holders on the studs.

5. Brushes tight in brush holders.—Clean the holders with gasoline and if brushes are still tight, sandpaper them down or file out the holders carefully.

6. Brush pressure too low.—Pressure should be 1¾ to 2¼ pounds per square inch cross-section for stationary motor and generators, 2½ to 4 pounds for elevator and mill motors, 3 to 5 pounds for crane motors, 4 to 7 pounds for railway motors.

7. Too low contact drop of brush.—Consult a brush manufacturer.

8. Insufficient abrasive action of brushes.—Use a commutator stone or more abrasive brushes.

9. High mica.—Use abrasive brushes, a commutator stone or undercut the mica.

10. Chattering.—Due to rough and dirty commutator, high mica, high bars, and flat spots.

11. Poor adjustment of interpoles.—Consult the manufacturer of the machine.

12. Overloads.—Undercut the mica, use low-friction brushes and check up all causes for short circuit currents such as: (a) Brush off neutral. (b) Faulty brush spacing. (c) Too thick brushes. (d) Unequal air gaps. (e) Crooked brush studs. (f) Too low contact drop of brushes. (g) Unbalanced armature winding.

13. Open circuit in armature coil.—Rewind that part of the armature.

14. Loose end connection.—Scrape and resolder all defective connections.

15. Worn bearings.—Shim or renew the bearings.

16. Unequal air gaps.—Shim the short poles or grind off the faces of the long poles, or if from worn bearings, see paragraph above.

17. Short-circuit currents between brush studs caused by unbalanced armature winding.—Consult the manufacturer of the machine.

18. Eccentric commutator on high-speed machine.—Turn or grind.

19. Poor belt lacing.—Re-lace or still better, use a continuous belt.

20. Pound of reciprocating engine driving the machine.

21. Unstable foundation.

22. Cross currents between generators operated in parallel driven by reciprocating engines due to variation in angular speed of engines.—Use heavier flywheel.

* Bulletin Published by the National Carbon Co., Inc.

Railway Electrification in Japan

At a recent Imperial Government Railway conference held in Tokyo a program was approved for the electrification of the Tokaido Railway Line between Tokyo and Akashi.

The money for electrification work was appropriated some time ago and the recent conference had for consideration only the development of a definite program.

The work under consideration at the present time consists of the portion of the Tokaido Line extending from Numazu to Akashi, a distance of approximately 300 miles. This work, not including the cost of locomotives, is estimated to require the expenditure of about $10,700,000.

In addition to the electrification of the Tokaido Line, the railway department has already prepared tentative plans for electrifying the Central and the Northern Lines.

While the foreign electric locomotives have so far dominated the field, at least one Japanese company is active in competing for this particular class of business. A trial locomotive has recently been completed and tested by the Hidachi Engineering Works, which in design embodies many features introduced by American manufacturers. According to reports, this Japanese trial locomotive has given good results in the recent test.

Elementary Theory of Alternating Circuits

A Series of Practical Articles Explaining a Difficult Subject in a Simple Manner

By K. C. Graham

Part V. Inductance and Capacity of Parallel Circuits

THUS far we have only considered the effects of inductive and capacitive reactance as applied to series circuits and we shall now take up the study of their application to parallel circuits. They may be combined separately with resistance in parallel; jointly with resistance in parallel; separately with resistance in series or jointly with resistance in series with the supply.

When a resistance and an inductance are connected in parallel it is a curious fact, but none the less true, that the current in the line wires may be out of phase with the voltage while that in the resistance is in phase with it and that in the inductance 90 degrees out of phase with it. This may be best explained by reference to Fig. 37.

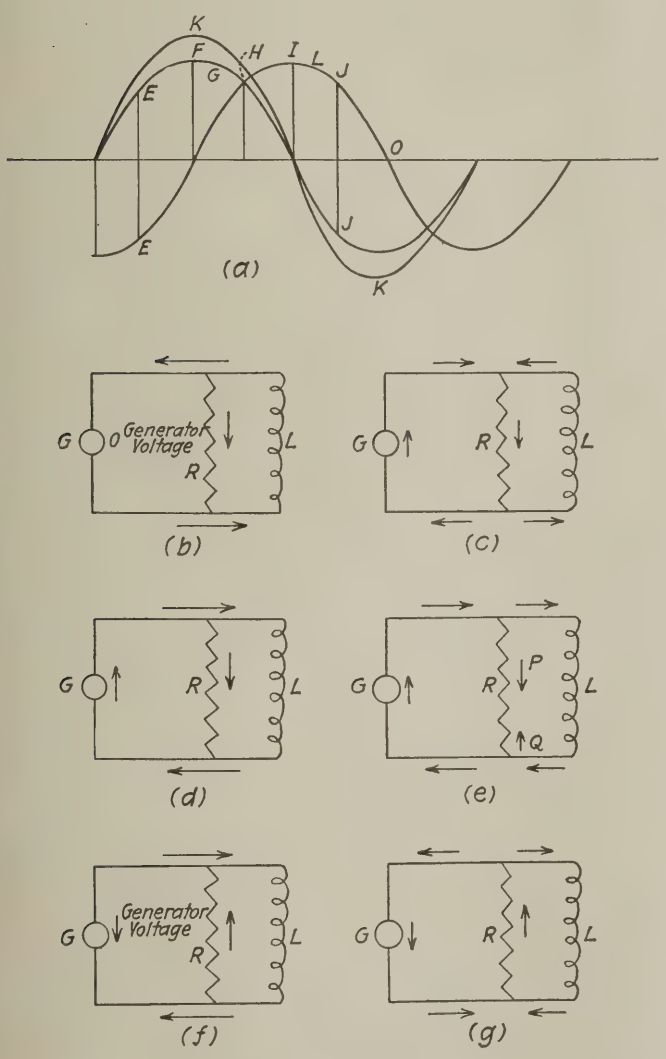


Fig. 37

Fig. 37 (a) represents counter voltage L lagging behind the generator voltage G by an angle of 90 degrees. K represents the current wave which, as we shall prove, is in phase with the voltage G. Starting at the zero point of the generator wave, the generator voltage is zero, while that of the inductance is a maximum and is just succeeding in overcoming the self-inductance of resistor R, Fig. 37 (b). Between zero and point E the generator voltage gradually builds up while that of the inductance is decreasing. The generator voltage is less than that of L and it is opposed to such an extent that it is not effective in sending current through the resistor. It will be noted, however, that the resistor is really connected across L's terminals so that L acts as a generator thereby forcing current through the resistor. At the same time that L is offering opposition to the voltage of G. At point E the two voltages are equal in value and, therefore, equally effective in forcing current through R as in Fig. 37 (c). From E to point F the generator overcomes the voltage of the inductance, at the same time continuing to force current through R as in Fig. 37 (d). After the inductance voltage has been reduced to zero the generator begins forcing current through it as well until at H the voltages of the inductance and the generator are again equal, but, this time, in the same direction as in Fig. 37 (e). From this point the generator voltage decreases while that of the inductance increases, the generator continuing to force current through R in the same direction as shown by arrow P, Fig. 37 (e) while the voltage of the inductance tends to send current through R in the opposite direction as shown by arrow Q. At point I the generator voltage is passing from zero to negative while the voltage of L is just succeeding in partly overcoming the self-inductance of R and thereby causing a small current to flow through R in the opposite direction, as in Fig. 37 (f). From this point the voltage of G increases while that of L decreases until at point J the two voltages are again equally effective in forcing current through R, as in view Fig. 37 (g). From J to the zero position the voltage of G increases while that of L decreases. Then we start through another cycle in the same manner. The result is that the current through the resistance is actually in phase with the voltage while the current through the reactance is 90 degrees out of phase with it. At the same time the current in the line is out of phase with the voltage an amount depending on the relative values of the resistance and inductance of the circuit.

Fig. 38 shows the effect of a capacitance connected in parallel with a resistance. By following through the various figures it is seen that the net result is the same as in Fig. 37 and the two parallel one another so closely that no attempt will be made to treat it in detail. It might be mentioned that L was represented as a pure inductance for purpose of illustration, but we should remember that there can be no such thing as a 100 per cent inductance because there is some resistance in every circuit. This

does not, however, alter the action as illustrated except that the current through the reactance is not quite 90 degrees out of phase with the voltage. I mention this point because it is necessary that we obtain a clear unblemished mental picture of the various phenomena of alternating currents if we are to thoroughly understand their application to generators, transformers, motors, etc., that we shall begin to study in the next chapter.

Calculations Relating to Parallel Circuits

The calculation of the impedance of parallel circuits is much the same as the calculation of parallel resistances in the study of direct currents.

In order to refresh our memory in this regard, let us

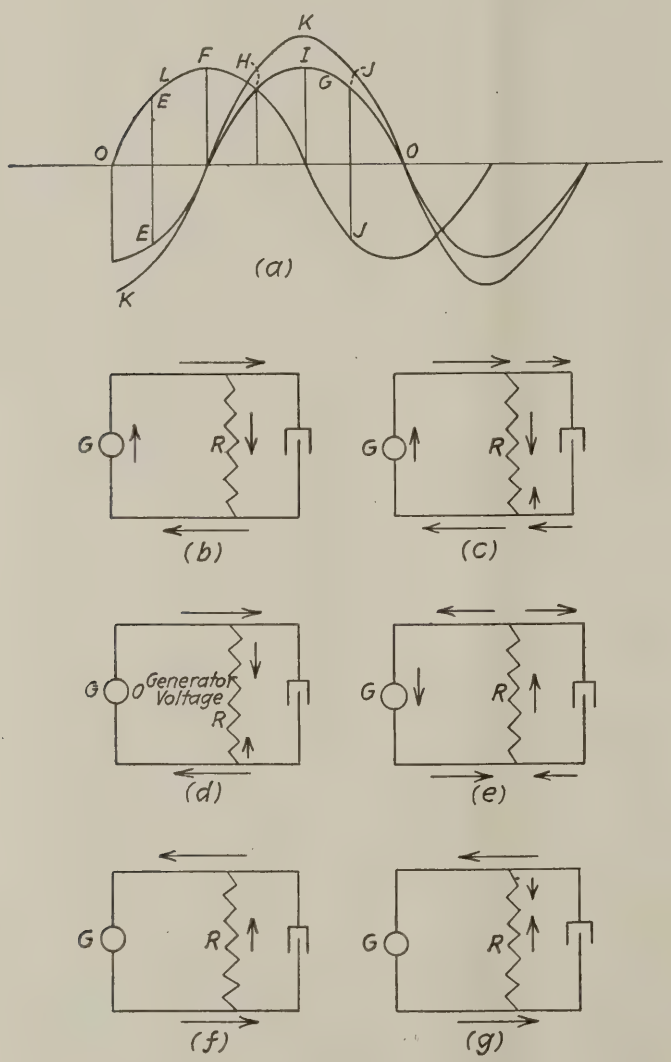


Fig. 38

refer to Fig. 39, which shows two resistances of two and three ohms respectively, connected in parallel. The conductance is that value obtained by dividing 1 by the resistance so that the conductance of *Ra* is one-half, and that of *Rb* is one-third. Now the combined resistance of the two is equal to 1 *divided* by the sum of the conductances; in this case

$$R = \frac{1}{\frac{1}{2} + \frac{1}{3}} = \frac{1}{3/6 + 2/6} = \frac{1}{5/6} = \frac{6}{5} = 1\frac{1}{5} \text{ ohms.}$$

Fig. 40 (a) shows a resistance R of two ohms connected in parallel with an inductance having a reactance of three ohms. The conductances are, respectively, one-half and one-third as in the direct current example. They cannot be added directly, however, to obtain the combined conductance because the currents through them are at 90 degrees to each other and, therefore, their resistances are not effective at the same time. They are combined in the

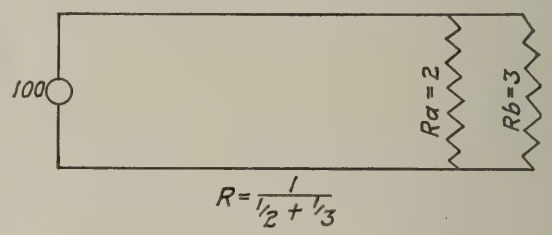


Fig. 39

same manner that we combined the resistances in the series circuits of the previous section. This is illustrated in view Fig. 40 (b) where it is seen that the combined conductance of the two is equal to approximately three-fifths. The impedance then, is equal to

$$\frac{1}{3/5} = \frac{5}{3} = 1\frac{2}{3} \text{ ohms.}$$

In the case of the resistance in parallel the current through the circuit would be 83⅓ amperes if the supply voltage were 100 while in the case of the resistance and reactance the current would only be 60 amperes. These values were obtained, of course, by the use of Ohm's law, which states that volts divided by ohms equals amperes. We have now covered practically all the mathematics involved in an elementary study of alternating current phenomena.

We have not yet considered the effect of resistance, inductance and capacitance in parallel, Fig. 41 (a), but this really presents no new difficulty. In this case we subtract the conductance of the smaller reactance from that of the larger and combine the result with the conductance of the resistance as in Fig. 41 (b). Here we subtract one-fourth from one-third and combine this with one-half,

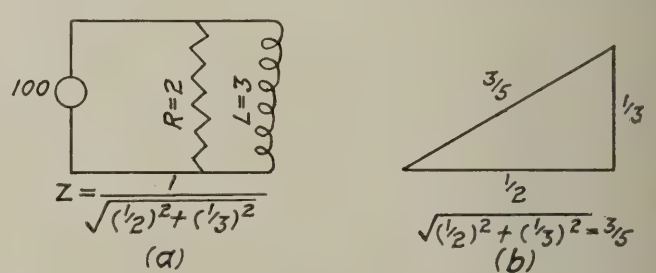


Fig. 40

obtaining a reactance of .51 ohms. The voltage divided by this value represents the current in the line.

Another case is that of a resistance connected in series with a reactance and another resistance, connected in parallel, Fig. 42. Here it is only necessary to obtain the combined resistance of the reactance and resistance that are in parallel, and then combine this result with the series resistance in exactly the same way as was done in the study of series circuits.

In the series circuits the current through the various resistances and reactances were the same as the line current, of course, because they were connected in series with each other in the supply circuit. The current in the resistances and reactances, of a parallel circuit are not the same as the current in the line. The current through any of the parallel sections is equal to the voltage divided by its resistance or reactance as the case may be. Thus if the voltage is one hundred and the resistance two ohms as in Fig. 40, then the current through the resistance is 50 amperes and that through the reactance of three ohms is 33⅓ amperes. These two must be combined by the tri-

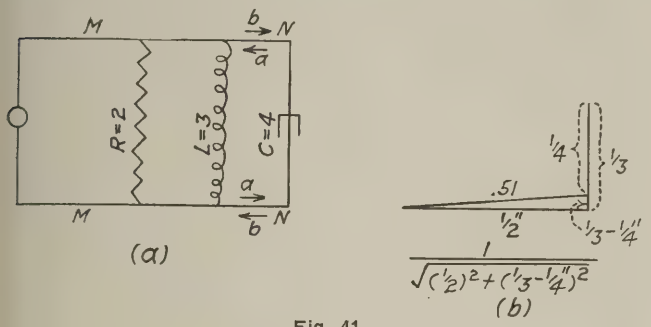


Fig. 41

angle method to obtain the line current, since they are not in phase with one another. This is found to be 60 amperes, Fig. 43. This value agrees with that obtained in connection with Fig. 40 thereby proving our method to be correct.

If the inductive reactance of a circuit is equal to the capacitive reactance the two will neutralize one another and the current in the line will be the same as if resistance only were present. Thus in Fig. 41, if the inductive and capacitive reactances are each equal to three ohms the sum of their conductances will be zero in Fig. 41 (b) instead of one-twelfth and the impedance will then be the ohmic resistance of the circuit. The current in wires *M* will be practically equal to the voltage divided by this value but an equalizing current will flow in the section *N* between the inductance and the capacity, first in one direction and then in the other, but will not affect the

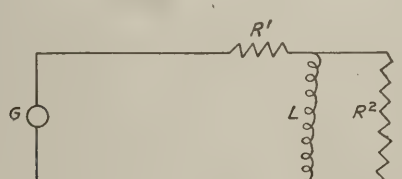


Fig. 42

main current. The line current will be slightly greater than that obtained by dividing the voltage by the ohmic resistance because enough power must be supplied to make up for that lost in the flow of current through the resistance of the wires *N* between the two reactances. When the inductive and capacitive reactances of a circuit neutralize one another the circuit is said to be in a state of resonance. In a series circuit the line current is actually equal to the voltage divided by the ohmic resistance of the circuit because no equalizing currents flow in the line due to the very fact that all parts of the circuit are in series.

It might be of interest to mention a bad result of a condition of resonance in a series circuit. If a reactance coil takes a current of one ampere when connected to a voltage of 100 its reactance is 100 ohms and its counter voltage is almost 100 volts. Therefore it would require 500 volts to produce 5 amperes of current through it the counter voltage would be 500 volts. In other words, if five amperes of current flow through it the voltage across its terminals will be 500. Thus if a resistance of 20 ohms, an inductive reactance of 100 ohms and a capacitive reactance of 100 ohms are connected in series the capacitance will neutralize the inductance and the current through the circuit with a terminal voltage of 100, will be 5 amperes. The voltage across the terminals of the inductance and of the capacitance will each then be 500. This value might be sufficient to break down the insulation of either of the reactances. Cases have been known where this fact has resulted in serious accidents. Thus a circuit will be operating normally until one of the reactances breaks down; if this happens when the voltage wave is at its peak the voltage of the other reactance will be impressed on the circuit and if the power stored up in the reactance is great enough it may cause such a large current to flow as to ruin other apparatus in the circuit. This represents what is known as a line surge and these surges have, at times been so great as to ruin power houses with resultant loss of life or injury to attendants.

Power

As has been mentioned before, the effect of reactance on an alternating current circuit is to displace the voltage

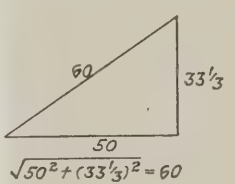


Fig. 43

and current waves with respect to each other so that the power active in the circuit is less than it would be in a corresponding direct current circuit or an alternating current circuit that is entirely devoid of reactance. We shall now endeavor to learn why this is so. We know that the power in a direct current circuit is equal to the product of the voltage of the circuit and the current flowing in it.

Fig. 44 (a) illustrates the familiar series circuit consisting of generator *G*, resistance *R* and reactance *L* with the necessary connecting wires. From *a* to *b*, Fig. 44 (b) the reactance of the circuit is active in forcing the current through the circuit while from *b* to *c* the voltage of *G* is active in forcing current through the resistance and reactance of the circuit. If *R*, the resistance, is a consuming device such as a heater, the current flowing in the circuit between the intervals *b* and *c* will be effective in heating it and also in building up energy in the reactance. Then as the voltage of the generator falls to zero at *c* the only voltage effective in the circuit is that due to the reactance. It will now cause a current to flow through itself, the generator and the heater. The power used up in forcing current through itself and through the generator is lost and only that effective in heating *R* is useful, so we may

say that the power stored up in L was practically all returned to the circuit. The energy consumed in forcing current through L between b and c is about equal to that necessary to force current through R between c and d so that we may obtain the power effective in the circuit by multiplying the voltage and current between b and c as in Fig. 44 (b). The reactive power of the circuit is equal to the product of the voltage and current between a and b or between c and d. It should be noted that the return of power to the circuit by the reactance is an actuality and not a mere figure of speech because if the generator is steam driven the steam will do no work between a and b of the generator wave because it is being driven as a motor, between these points, by the current from the reactance. The flow of this reactive current through the generator serves no useful purpose but, on the other hand, uselessly heats up the windings thereby limiting the maximum load that the generator may carry; the maximum load depending on the maximum allowable heating of the windings. This reactive current is sometimes called the wattless current of the circuit and the reactive power is called the wattless power of the circuit.

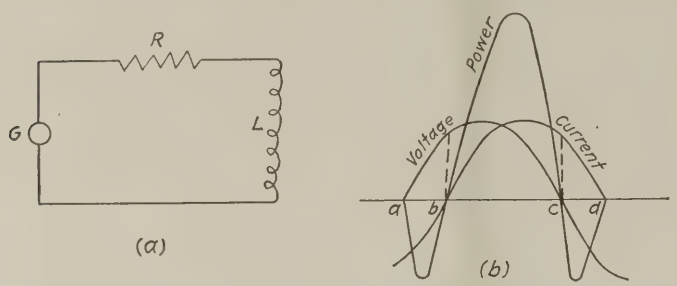


Fig. 44

Fig. 45 shows the product obtained by multiplying the voltage by the amperes as if the current were in phase with the voltage. This is seen to be considerably greater than that actually effective in the circuit so that the result

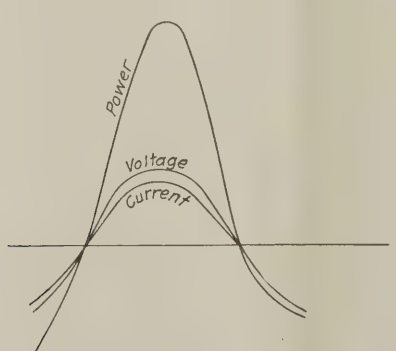


Fig. 45

obtained by multiplying the reading of a voltmeter connected across the circuit and that of an ammeter connected in the circuit does not represent the power in the circuit. To obtain the power active in the circuit we must multiply this value by a decimal representing what is known as the *power factor* of the circuit. We shall now proceed to discover the meaning of this expression.

Fig. 46 (a) shows the current I lagging behind voltage V by an angle K corresponding to the angular distance of a—b, Fig. 34 (b). This feature was explained in connection with Fig. 34 and therefore needs no further mention here. The *cosine* of this angle represents the value by which product of voltmeter reading and ammeter reading must be multiplied to give the active power of the circuit and is called, as mentioned above, the power factor of the circuit. Fig. 46 (b) illustrates what is meant by the cosine of the angle. The hypotenuse of the right triangle is 5 units, the vertical side 4 units and the base 3 units. Now the cosine is the relation between the base

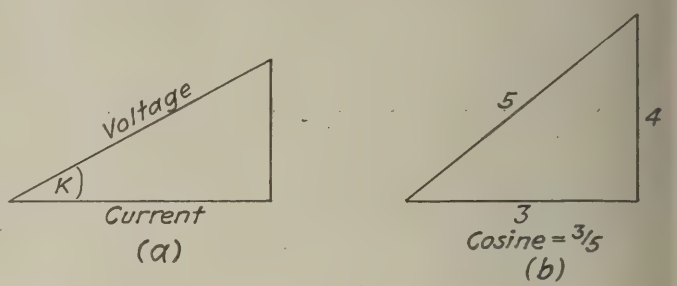


Fig. 46

and the hypotenuse, in this case the relation of 3 to 5 or $\frac{3}{5}$. Expressed decimally this is equal to six-tenths so that the power-factor of the circuit is said to be six-tenths. Thus if the voltage of the circuit is 100, the current 10 amperes and the power-factor .6, the product of volts and amperes will be 1000 while the product of volts, amperes and power-factor is 600. Thus the apparent power of the circuit is 1000 watts while the actual power is only 600 watts. The product of volts and amperes alone is not called watts in alternating current circuits but is called volt-amperes to distinguish it from the actual power in watts which is obtained by multiplying this value by the power-factor. An alternating-current wattmeter measures actual watts as will be seen later when we take up the study of measuring instruments.

While the majority of German electrical companies complain of lack of orders both from domestic and foreign buyers, certain of the manufacturers are apparently working to good capacity. One of the largest manufacturers of wire and cable stated that the factory is working full time in all departments.

P. & A.

Scene of Disastrous Collision in Switzerland

Gas-Electric Motor Car Developed by the Electro-Motive Company, Cleveland, Ohio.

The Gas-Electric Motor Car is Reinstated

Northern Pacific and Chicago Great Western Will Use New Developed Type of Passenger Car

THE first cars of the new type of gas-electric passenger car have just been delivered, one each to the Chicago Great Western and the Northern Pacific. The cars were built by the Electro-Motive Company, Cleveland, Ohio, and the General Electric Company. They have been in process of development during the past three years.

The cars are driven by a 175 hp. gasoline engine, direct connected to a 110-kw. 700-volt generator which supplies power to two railway motors mounted on the power truck. They weigh approximately 70,000 lb. each, are 57 ft. 4 in. long over the body, by 9 ft. 9⅜ in. over the belt rail, and have a maximum seating capacity in the passenger compartment of 59 persons, with 72 sq. ft. of floor space in the baggage compartment. The seats on one side are 54 in. long and on the other side 37 in. long, seating three and two persons per seat, respectively. The aisle clears 22 in. wide.

The car bodies and trucks were built by the St. Louis Car Company. The car bodies are of steel construction with an underframe, the design of which is considered sufficiently rigid to withstand the shocks and buffing strains caused by occasional impacts with heavy standard equipment. They are equipped with single windows, but the frames are designed to receive additional storm windows. The floors are double with 1-in. hair felt insulation between. The side walls are similarly insulated up to the height of the belt rail, behind the letter board and under the roof. The entire design conforms closely to steam railway practice.

The car body is divided into four sections. At the front is the engine compartment, which is 8 ft. long. This contains the engine-generator set, the radiator and cooling fan, the air compressor and the operator's station, with the necessary gages and controls. Behind this are, in their order, the baggage and passenger compartments. At the rear is a vestibule with side door entrances, which is 6 ft. 3 in. long. This contains the toilet.

The Motor Truck

The power truck is a high-speed electric railway type, built with M. C. B. journals and bearings and equipped with two 105-hp. General Electric railway motors. The motors are of the G. E. 240-A-600 volt, series commutating pole box frame type. They are oil lubricated, self-ventilated and are mounted directly on the axles of the truck with bar suspension. This truck carries a load of 41,000 lb. at the rail. The cars have sufficient power to pull a standard 30-ton coach and make schedule speed in average branch line service. The maximum speed for which the car is designed to run on level grade is 50 miles per hour. Operating at this maximum speed under level grade conditions and making stops of one minute duration averaging eight miles apart, the maximum average schedule speed of which it is capable is 40.2 miles per hour. On the basis of the same conditions as to the frequency and duration of stops, the maximum average schedule speed decreases as the grade increases, to 22.8 miles an hour on a 2 per cent ascending grade.

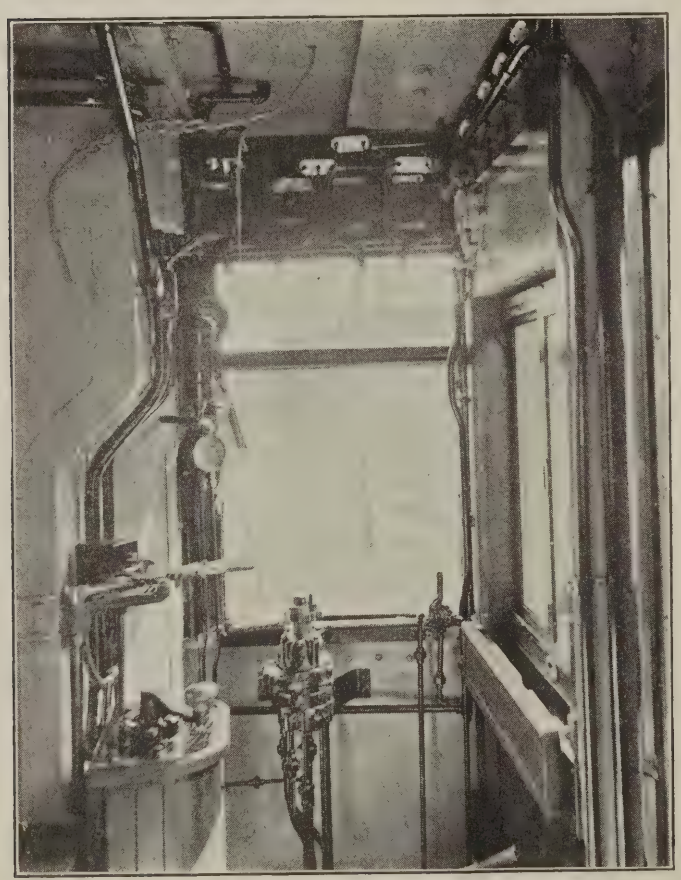
Before work was started on the car, an extensive survey was made to determine, first, the size in greatest demand and, second, the performance requirements. This survey indicated quite clearly that while there was a demand for cars of various sizes, a car seating 55 to 60 passengers with 75 to 100 sq. ft. of baggage space and with sufficient power to pull a 30-ton standard coach over grades of 1½ to 2 per cent, making the average branch line schedule, came the nearest to meeting most motor car requirements.

Additional requirements which it was found should be met are a high rate of acceleration and provision for double end control.

The General Electric Company already had built more than 90 gas-electric motor cars from 1908 to 1912, some of which have passed the million mile mark in service and are said still to be showing remarkable operating economy. The problem, therefore, was to develop a new car around the old. Great strides have been made in the development of the gas engine and in electric practice since the original gas-electric cars were designed, and the experience with the old cars was also invaluable.

Engine and Generator

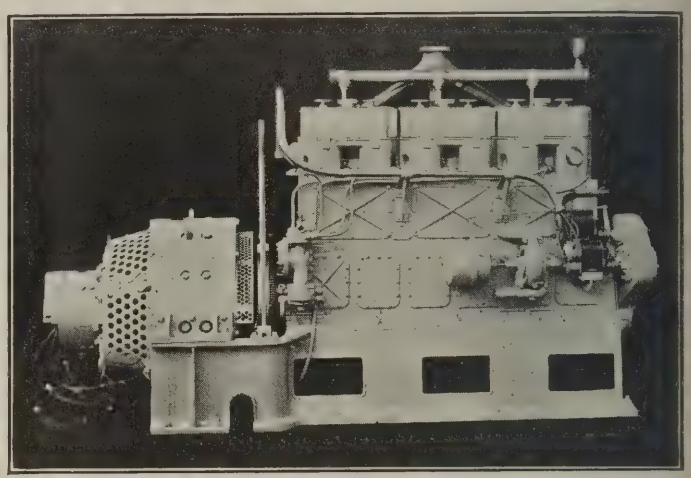
The survey indicated that the car should not exceed a light weight of 35 tons and, furthermore, that it should be equipped with a railway type engine rather than an automotive, stationary or marine type, as these all have characteristics not suited to railway service. The Winton Engine Works, Cleveland, Ohio, co-operated in the new development and a railway type gas engine was designed around a marine type which has been in successful service



Operator's Compartment Showing Control Apparatus

for years. This engine has six cylinders of 7 in. bore by 8 in. stroke, with overhead valves and develops 175 hp. at 1,000 r.p.m. It is of rugged construction having a 4-in. crank shaft supported in seven main bearings carried in the lower half of the engine base, thus forming a firm foundation for the revolving and reciprocating parts. The cylinders are built up of a special grey iron water jacket cast in one piece, with cylinder sleeves of semi-steel inserted. The cylinder heads, which are cast in pairs, contain all intake and exhaust passages as well as the valve seats. This entire cylinder and cylinder head assembly is bolted to the upper half of the aluminum crank case. In the design of the engine the problem of its maintenance on the railroad has been carefully taken into consideration. All working parts have been made accessible and the engine is so mounted that any assembly or part of it may be repaired without disturbing the auxiliary apparatus. United States standard threads and bolt sizes have been used throughout.

The generators is a 110 kw. 6-pole, 700-bolt commu-



The 175-hp. Gas Engine-Generator Unit Which Is Placed Transversely Over the Forward Truck Bolster

tating pole type machine. It is self-ventilated and is equipped with outboard bearings.

Control

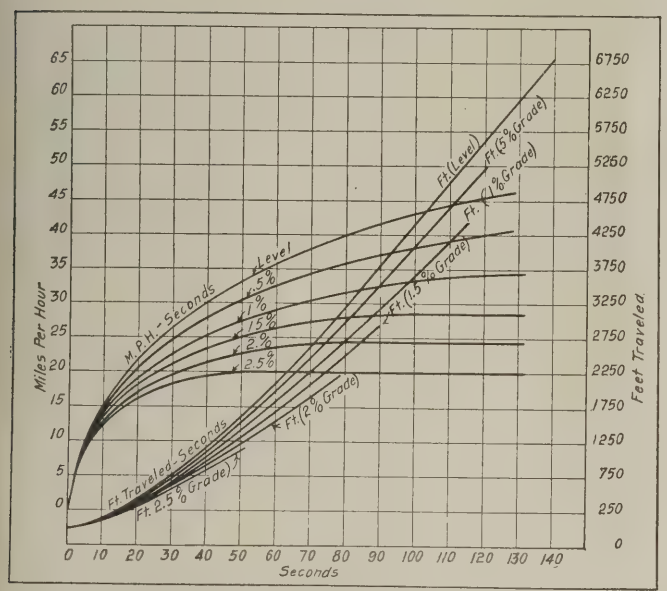
Since the power of the engine is transmitted electrically, the location of the engine and generator is not fixed by the requirements of transmission. In this car, instead of being located along the longitudinal center line of the car at the forward end of the engine room, the engine and generator unit are located transversely directly over the center of the truck at the rear of the engine room. The body bolster for the forward truck is designed to form the engine foundation. The operation of the car is controlled by what is termed locomotive control, embodying field control of the generator and throttle control of the engine. The apparatus consists of a series-parallel control with forward, backward and neutral positions, in any one of which a wide range of speed control is available by the locomotive type throttle directly connected to the engine carburetor. No automatic mechanism is involved in this type of control and a locomotive engineer has no difficulty in learning to control the car successfully after a few minutes' practice.

The electric transmission permits a high acceleration and torque at low speed and permits of operation in both directions with equal performance. The engine speed has no direct relation to the car speed and hence the maximum power of the engine can be utilized at low car speed under severe operating conditions while, on the other hand, a high car speed may be obtained with a low engine speed when low power output is required, thus tending to promote fuel economy and low engine maintenance.

Three methods of starting the engine are available. A 32-volt starting motor, drawing current from a storage battery, engages the fly wheel. There is also a compressed

air starting device which supplies air from the main reservoir of the brake system through a distributor on the cam shaft to each of the cylinders. A standard car hose connection is fitted to the main reservoir pipe so that air may be drawn from any outside source available in emergencies. An effective hand cranking device is also supplied which may be operated with ease and without danger to the operator.

The engine cooling system includes a radiator of ample size which is mounted in the front end of the car, air being drawn through it by an electric motor-driven fan controlled by a thermostatic governor. The radiator is



Calculated Time-Speed and Time-Distance Curves for the New Gas-Electric Car

equipped with a manually controlled shutter so that with the variable speed fan and a conveniently located engine temperature gage, a uniform engine temperature, irrespective of atmospheric conditions, may readily be maintained. A convenient connection between the hot water car heating system and the engine cooling system is provided to keep the engine and radiator warm and from freezing when the car must be tied up where there are no terminal facilities. A 32-volt storage battery provides current for car lighting, generator excitation and motor cranking. This battery is charged by a 1½-kw., 32-volt generator mounted on the main generator shaft.

The Chicago Great Western car was operated from the plant of the St. Louis Car Company, St. Louis, Mo., to Chicago, over the line of the Chicago & Alton. At Granite City, Ill., the car picked up a train crew and caboose which weighed 36,000 lb., and, with this load, was able to make passenger train schedule time over the Alton hill with its 1.4 per cent grade.

The average schedule time from Bloomington, Ill., to Chicago was 43 miles an hour and the average gas consumption for the entire trip was 4 miles per gallon. On the trip two operators handled the car, neither of whom had had any previous experience with it. For the first half of the trip a member of the Electro-Motive Company organization handled the car and on the last half of the trip, a representative of the Chicago Great Western.

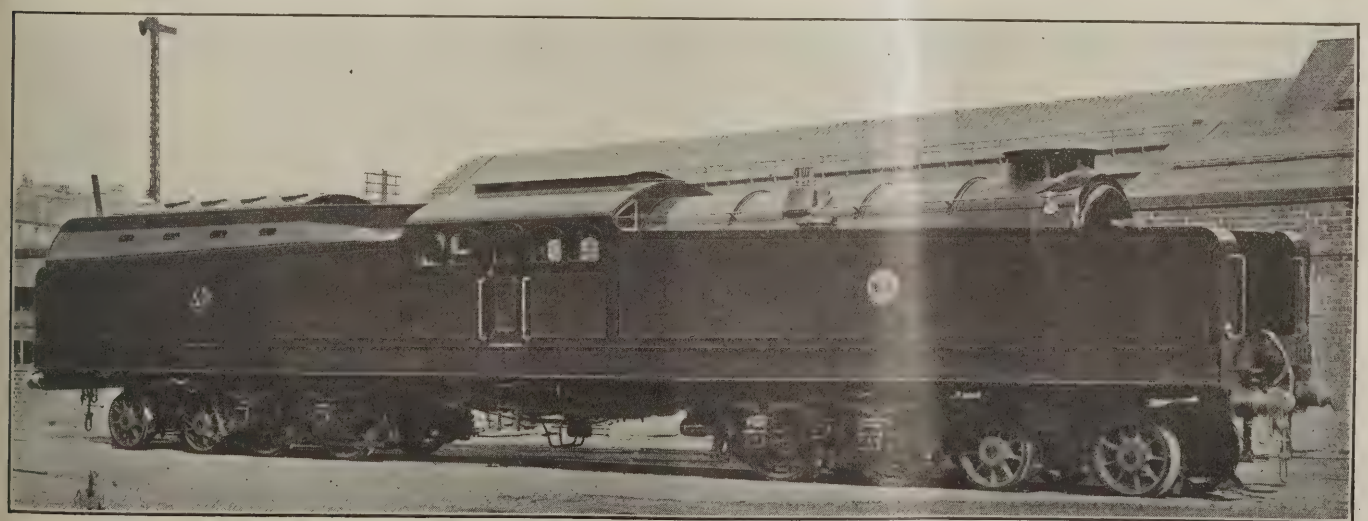
One of the illustrations shows a theoretical time-speed distance curve calculated for these cars. Such tests as have so far been made indicate considerable improvement on what is shown in the diagram. One acceleration test included starting the engine and getting the car under way to a speed of 30 miles an hour in 33 sec.

The Northern Pacific car which is the first of a proposed new series designed to provide additional service on Northern Pacific lines was received from the car builders on August 28. It will be placed in service on the main line between Staples, Minn., and Fargo, N. D.

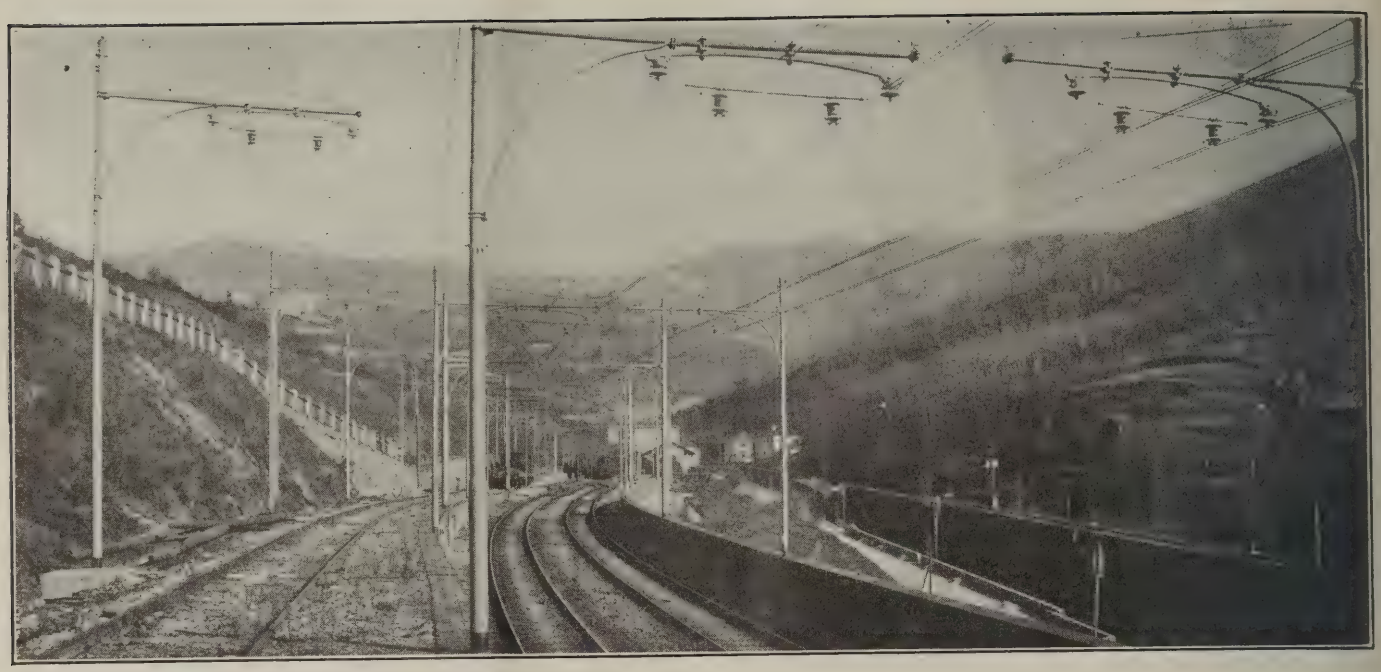
Tests on street and level track, on curves and grades were made between St. Paul and Duluth, Minn., with general manager C. L. Nickols and other officials on board to witness the car's operation and the car was also operated through the Minneapolis and St. Paul terminals. Tests were made with the car hauling a passenger coach.

The Northern Pacific, it was stated by A. B. Smith, passenger traffic manager, plans to use this and similar cars to provide additional service on branch as well as main lines. The gas-electric car will supplement and supplant steam power between Staples and Fargo. The length of this run is 102 miles.

Two other motor cars are already in operation on the Northern Pacific. Both are straight gas cars.



Turbine Locomotive Built by North British Locomotive Company, Ltd., Glasgow, Scotland—A Competitor for Honors with the Electric Locomotive



Electrified Section of the Italian State Railways Near Genoa

Electrification Progress and Power Supply

Status of Railroad Electrification in Various Countries Presented at First World Power Conference

ELECTRIFICATION of railroads was given a prominent position at the First World Power Conference recently concluded at Wembley, London, England. The purpose of the conference was to consider how industrial and scientific sources of power might be adjusted nationally and internationally, (1) by considering the potential power resources of each country, (2) by comparing experiences in the development of agriculture, irrigation and transportation, (3) by conferences of engineers, (4) by consultations of power consumers, (5) by conferences on technical education, (6) by discussions on the financial and economic aspects of industry, and (7) by conferences on the possibility of establishing a permanent world bureau for the collection of data. Brief abstracts of the several papers presented on electrification follow.

Electrification of Railways in Norway

Considering the railway problem and especially the electrification of the Norwegian railways, one has to bear in mind the particular features of the country.

The area of Norway is equal to that of the British Isles, and the country is for the greater part very mountainous. Its total length is several times the length of England and Scotland together, as the distance from "North Cape" to its southernmost point is more than 1,250 miles. On this area there live only about three million people. It is therefore easily understood that there are great technical as well as economic difficulties in the way of building railways in Norway. The mountains and tunnels make the railways expensive and the rather small traffic makes a profitable railway the exception.

It has therefore never been attractive to private enterprise to build railways in this country, and the state has for the greater part been compelled to do it, putting the expenditure on the tax-payers. For this reason there are still relatively few railways in Norway. The total length of line is at present about 2,200 miles, single track about 2,600 miles.

For many years to come the state authorities will have to concentrate their efforts on building those main lines that are still wanted, and at the same time on trying to reduce the operating cost of the railways built. Here, the nature of the country may be of assistance. Norway is, as is well known, one of the countries where water power is most abundant; on the other hand it has no coal mines. The waterfalls are often situated close to the railway lines. It is therefore natural to replace the foreign coal by the "white coal" for those railways whose traffic and other conditions are well suited for electrification. The Norwegian government, therefore, has already started such electrification, and at present three sections of the state railways are electrically operated, and two further sections are being electrified. The single-phase system at about 15 cycles and approximately 15,000 volts has been adopted. Also two privately owned railways are electrified. The following tabulation lists the railroads which are already electrified and those in progress of being electrified:

ELECTRIC RAILWAYS

1. "Thamshavn" railway. Privately owned. Length, 10 miles. Track gage 1.0 meter. Single-phase alternating current, 6,000 volts, 25 cycles.
2. "Tinnos" railway. Originally privately owned, now a State railway. Length, 18.7 miles, standard track gage. Single-phase alternating current, 10,000 volts, 16⅔ cycles.
3. "Rjukan" railway. Privately owned. Length, 10 miles,

standard track gage. Single-phase, alternating current, 10,000 volts, 16-2/3 cycles.

4. "Drammen" railway. Length, 33 miles of which 8.1 miles is double track. Standard track gage. Single-phase alternating current, 15,000 volts, 15 cycles.

5. "Ofot" railway. Length, 26 miles, standard track gage. Single-phase alternating current, 15,000 volts, 15 cycles.

The "Drammen" railway has a rather large passenger service, the other railways a rather large freight service.

RAILWAYS WHICH AT PRESENT ARE IN PROGRESS OF ELECTRIFICATION

6. "Hovedbanen" (Section Kristiania Lillestrom). Length, 13.7 miles, double track. Standard track gage. Single-phase alternating current, 15,000 volts, 15 cycles.

7. Section: Drammen-Kongsberg. Length, 28.6 miles. This section is the continuation of the "Drammen" railway.

The above mentioned railways (1-5) are put down in the order in which they have been electrified.

Power Problems of the Swedish Railways

At the present time only one link in the Swedish State railway system is electrified, namely, the Svartön-Riksgränsen line. This line, which is principally used for the export of ore from the iron mines at Kiruna and Gällivare to the harbors at Narvik and Svartön, has a length of 270 miles, to which should be added 16.7 miles of branch lines, which are also electrified. The connecting line through Norway from Riksgränsen to Narvik, which has a length of 27 miles, was electrified in 1923. The total electrified line Svartön-Riksgränsen-Narvik is thus 296 miles. It is therefore the longest electrified railway in Europe at the present time.

The section from Kiruna to Riksgränsen, 81 miles, was electrified in 1915; in 1920 the line Kiruna-Gällivare, 62 miles, was opened for electric service, and in 1922 the electrification was completed of the whole line down to Svartön.

Single-phase current at 15 cycles and 16,000 volts is used for the contact wire. The whole line Svartön-Riksgränsen-Narvik is supplied from the Porjus hydro-electric station on the Lule Alv. In this power station are installed four single-phase generators for traction, one of which is used as a reserve. Each generator has a continuous output of 6,000 kva. and maximum output of 10,000 kva.

The traction energy is generated at 4,000 volts, 15 cycles. Transformers with a 4,000/40,000 volts ratio, feed the long distance transmission line at 80,000 volts, the transformers being connected in parallel on the low voltage side and in series on the high voltage side. There are really two transmission lines, one running north to Vassijaure near Riksgränsen and from there through Norway to Narvik, and one running south to Notviken near Luleå. The total length of the transmission lines is 32.5 miles. The transmission lines supply 15 sub-stations, about 21.6 miles apart.

At each of these sub-stations two or three 80,000/16,000 volt step-down transformers are installed for feeding the overhead contact wire, and certain auxiliary circuits for the stations. The transformers are rated from 1,100 to 1,500 kva., are oil-cooled, and are so arranged that they can be easily sent by rail on a special car to the repair depots at Kiruna and Notviken, when necessary.

The transmission lines are double, four wires being necessary for the two circuits, and are carried on three- or four-legged steel towers, 55 ft. to 70 ft. high. The maximum sag is 32 ft. and the minimum height above ground is 28 ft. The span averages 640 ft. with a maximum of 1216 ft. Four-legged anchoring masts are placed at intervals of 9 or 11 spans.

The overhead contact line is of a simple catenary pattern, the contact wire being supported from the catenary wire at the supports and at two or five intermediate points, the total span being 178 ft. on straight open track. The contact wire is hung in independent sections of 4.5 ft. length, stretched at each end by counterweights.

The rolling stock comprises 4 express, 1 passenger, 33 mineral, 12 freight and shunting locomotives and 2 motor-cars.

On top of the trolley-poles are mounted two insulators, each carrying one ¼ in. steel wire. These wires are used for transmitting 60 cycle single-phase current at 10,000 volts to all stations and certain other places along the road. The voltage is stepped down to 220 volts at such places by means of small transformers—usually of 3 kilowatts—mounted on the trolley-poles. In this way all buildings along this road are supplied with electric light, and also electric power for other purposes.

Private Lines

Of Swedish privately owned railways, the following are electrified. The table gives the length of system in miles and the year when electric operation began.

	System	Length	Year
Stockholm-Djursholm	D.C. 600 volts	9.6	1893
Hälsingborg-Råå-Ramlösa	D.C. 600 volts	4.9	1906
Mellersta Östergötland	A.C. 10,000 volts 25 cycles	44.5	1908-1915
Stockholm-Saltsjöbaden	D.C. 1,200 volts	11.2	1913
Lund-Bjärred	A.C. 16,000 volts 16-2/3 cycles	6.8	1916
Nordmark-Klarälven	A.C. 16,000 volts 25 cycles	93	1921-1922

Of these electrifications that of the Nordmark-Klarälven railway is the most interesting one. Experience from this electrification has shown, that it is possible to operate a single-phase electric railway of 92 miles length, from only one feeding point, located about the middle of the line, without disturbing telephone and telegraph lines which run parallel to the railway, provided that these lines—as is here the case—never approach the track closer than 700 ft.

It has thus been proved—contrary to earlier assumptions—that it is not necessary to divide the contact line of an electrified railway into sections of about 18.5 miles, with one feeding point at the middle of each such section. For the electrification of the Stockholm-Göteborg line, which is now being built, it was therefore possible to choose much longer contact line sections.

The Electrification of the State Line Stockholm-Göteborg

The Stockholm-Göteborg line is a cross-country line in the southern part of Sweden with a length of 298 miles. The transportation consists of passenger and freight trains. Single-phase current at a frequency of 16⅔ and 16,000 volts on the trolley line will be used for this electrification.

The necessary electric energy will be taken from the State-owned system of main three-phase transmission lines, at five sub-stations near the railway line. At each of the converting stations will be erected motor-generators for changing the three-phase current into single-phase current. The three-phase lines have different ten-

sions, varying from 50,000 to 130,000 volts, which will be transformed down to 6,000 volts for the motors in the sub-stations. The single-phase current will be generated at 3,000 volts, and stepped up by means of transformers to 16,000 volts.

In two of the sub-stations at Södertälje and Alingsås there will be installed three motor-generator sets and in the other sub-stations two sets. All these motor-generators will be alike and each will have an output on the single-phase side of 2,400 kva. continuously with a maximum of 4,800 kva. Each sub-station will feed its own separate section of the trolley-line system. These sections will vary in length from 46.5 to 87 miles and will each be sectionalized in front of the sub-stations.

The trolley line will be built with an insulated copper cable for the return current. This return cable will be connected to the rails at every .6 mile on the first 12.4 miles from the sub-stations and at every 1.7 miles on the rest of the section. Drainage transformers will be connected in the trolley line and the return cable at points midway between the connections from the return cable to the rails. No bonding is in this case necessary for the rails and the track can be handled without any precautions for preventing danger to repairmen. This is of course a feature of the utmost importance.

For the Stockholm-Göteborg electrification 50 electric locomotives are ordered, which will be delivered in 1925. All the locomotives will be alike. The locomotives, however, will be made with two gear reductions and two speeds, one for passenger service and one for freight service. In passenger service the locomotives will haul trains weighing up to 500 tons with speeds up to 55.5 miles per hour and in freight-service they will haul trains of up to 900 tons with speeds up to 44 miles per hour. From the beginning, 10 locomotives will be allotted for passenger and 40 for freight service.

The Stockholm-Göteborg line will be completely electrified by the end of 1925.

Power Consumption

The power consumption for four of the electrified Swedish railways is given in kilowatt hours per year in the table below.

	Svartön—Riksgränsen	Nordmark Klarälven	Mellersta Östergötlund	Lund—Bjärred
1916	10,000,000	.....	740,000	103,000
1917	8,378,000	.....	639,000	159,000
1918	7,637,000	.....	593,000	153,000
1919	7,984,000	.....	659,000	160,000
1920	9,508,000	.....	675,000	167,000
1921	28,451,000	1,234,000	701,000	181,000
1922	36,943,000	2,229,000	785,000	175,000
1923	*41,158,000	2,463,000	800,000	177,000

*This includes 1.901.000 kilowatt-hours which were consumed by the Riksgränsen-Narvik electrification.

For the Stockholm-Göteborg electrification the power-consumption is estimated at 50 million kilowatt-hours per year.

Electrification on the State Railways in Germany

The total length of main line electric railways operated by the State Railway Department in Germany with single-phase alternating current is nearly 372 miles.

With regard to single-phase or three-phase alternating current, the latter, with a standard frequency, appears to be preferable, because it can be supplied from public supply power stations. The demand for energy for heavy traffic is, however, usually so great that special generating sets with separate switchgear and also separate feeders are required. For this reason the three-phase plant available for public supply cannot very well be used also for traction purposes.

Furthermore, in view of obtaining the highest degree of reliability, it is considered most desirable to supply lines with current from a power station which primarily produces traction current; if possible, the power station should be owned by the railway authorities.

For the sake of economy, it is therefore not necessary to adopt three-phase current for traction purposes. The State Railway Department in Germany has adopted single-phase alternating current with a frequency of 16 2/3 periods per second, and a line pressure in the trolley wire of 15,000 volts.

Constructional Features

The feeders for carrying the high-tension single-phase current from the power stations to the sub-stations are not run along the track on ten masts for supporting the trolley wires, as formerly; they are also not run at a distance, for instance, across hilly country in order to cut short any curves in the track. The arrangement standardized is to carry the transmission wires on a separate row of poles erected at a distance from the track of not more than 160 to 320 ft., where they are readily accessible. The standard pressure is 110,000 volts.

The trolley wire suspension is as simple as possible. The design is uniform throughout the State Railways in Germany; the number of spare parts that have to be stocked is therefore exceedingly small. The overhead equipment consists of a firmly attached messenger cable, which carries the trolley wire by means of suspension wires. The conductor has a section of 100 sq. mm., and is adjustable; it is erected with a 2200 lb. pull. A profile has been selected which reduces to a minimum wind stresses and the accompanying side drift. With the above pull and the permissible wind load the masts may be placed at intervals of 224 to 288 ft., according to local conditions.

Special care is taken that the overhead equipment does not prevent the driver from seeing the signals. With this end in view extensive use is made of cross-cable suspension in railway stations. This, moreover, affords the great advantage of doing away with poles between sets of rails.

Reinforced concrete masts, formed by a rotary process, are considered advantageous; they require neither supervision nor maintenance.

In the case of electric locomotives for the main lines of the State Railways in Germany it was possible to reduce the number of different types to six. There are now two types each for fast trains, passenger trains and freight trains, viz., one for hilly districts and one for flat level lines.

The advantages of having only a few standard types are found in the small number of spare parts and greater convenience both for running and inspection and repair in the shops. Standardization has been further introduced on all the latest designs of locomotives, inasmuch as the same collectors, oil switches and air compressors are now used on all machines.

In practice the power developed by an electric locomotive is determined on the State Railways in Germany by means of a special test car. The equipment of this car is arranged for measuring the electrical energy consumed, and the tractive force exerted at the draw-bar, so that the

overall efficiency of the locomotive can be determined. Other data, such as the power factor, temperature rise of the motors and the transformers, can also be measured. Further details disclosing the conditions on the locomotive are determined; they refer specially to the distribution in electric power taken by the locomotive.

Electric operation of locomotives permits the use of high speeds, especially on up grades, without affecting the economy of undertakings. Careful investigations were, for instance, made on the operation of the main line Breslau-Arnsdorf in Silesia. It was found that by increasing the average speed of freight trains from 18 miles per hour, at present, to 28 miles per hour, the running costs per annum for steam operation rose above 3.25 per cent. The corresponding increase in running costs with electrical operation under exactly similar conditions was found to be not more than 0.9 per cent.

It is desirable to raise the average speed of freight trains, because it is thereby possible to increase the number of trains running on the track, so much so that the construction of a further set of rails may become unnecessary.

The Influence on Telephone and Telegraph Wires

A point formerly raised against the use of single-phase alternating current was the influence of the electric and magnetic field of the single-pole overhead line, including the earth return, on telephone and telegraph wires near by. It has become possible to reduce this influence, so that there is no disturbance in the operation of the wires required for communication purposes.

The State Railway Department in Germany has not introduced new parts, such as boosting transformers in the traction circuit or special relays, bridge connections and the like in the telephone and telegraph circuits. The tendency has been, instead, to design the necessary parts for operating the system, such as generators in the power station and motors on locomotives, in such a way that current and pressure in the trolley wire are, as far as possible, not accompanied by higher harmonics.

The available means for reducing higher harmonics consist in providing the salient poles of generators with pole-shoes of a suitable shape, of a fine pitch for the slots in turbo-alternators and a slanting position and suitable number of the slots in motor armatures.

The comparison between motors of older and quite recent design, made on the test-bed, shows the considerable difference in the shape of the curve.

The following are the alterations made to telegraph and telephone lines. Overhead wires for public service running alongside the track of steam railways are generally shifted further away from the track when changing over to electric traction. Static effects will then disappear, and inductive effects are reduced to reasonable proportions. Telegraph, telephone and block-signalling wires are laid underground in cables, consisting of twin-stranded cores with, as far as possible, equal capacity to earth. The lead sheathing and armoring is designed to give a free passage to induction currents. Care is taken to obtain good joints between the covering of the core and the joint boxes. By inserting special wires under the lead sheathing the induction current is increased.

Long telephone lines are connected at the end of the electrified section to transformers provided with ample insulation. The telegraph lines for permanent current operation with line relays in series are connected with half the relay winding and the battery in each branch (symmetrical connections). Where such telegraph lines are continued beyond the electrified portion, a relay is inserted.

Rail bonds are not required for transmitting the traction current; it has, however, been found that rail bonds will reduce the induction pressure in the cables to the extent of 30 to 35 per cent.

The Electrification of the Austrian Federal Railways

Thorough and long study showed that the wealth of coal admitted of economical electrification of Austrian railroads on heavy gradients only. On the other hand, after the war, the coal mines being almost entirely lost, electrification became an immediate and urgent necessity, the natural stock of coal in Austria being reduced to 1.2 per cent which could meet the country's full demand for only twenty years.

The principal reasons for electrification in Austria may be considered to be:—

1. Political and economical independence of importation and price of coal.
2. Economy of service, especially on lines with heavy gradients (up to 3-1 per cent), and on places far from the coal importing centres (some of them over 435 miles distant). Even with the German Saar-coal now being used, which is 30 per cent cheaper than Polish coal, electrification is economical on heavy gradients and on lines with heavy traffic.
3. Increase of medium train speed on gradients, by obviating the need for taking in fuel and water.
4. Increase of capacity of transportation by the increase of speed and reduction of dead weight. In many cases, the necessity of building a second track can be avoided (for instance on the Arlberg line traffic can be increased to more than 30 per cent, while the building of a second track would cost more than $14,000,000.
5. Cleanliness and absence of smoke in tunnels. Possibility of running longer trains through tunnels.
6. Employment of Austrian industry, which is able to furnish almost all the necessary installations and work for the numerous laborers and workmen.

The following lines are going to be electrified (the highest grades in percentage are put in parentheses):

(*a*) Innsbruck-Lindau (Buchs, St. Margarethen) or the Arlberg line—147 miles single track (3.14).

(*b*) Salzburg-Wörgl—119 miles double track (2.3).

(*c*) Schwarzach-St. Veit-Villach or the Tauern line—72 miles single and double track (2.8).

(*d*) Steinach-Irdning-Attnang-Puchheim or the Salzkammergut line—66 miles single track (2.5). These lines which are included in the first program amount to 389 miles and need 120 millions kilowatthours yearly.

(*e*) Additional lines: Kufstein-Wörgl-Innsbruck-Brenner (formerly Southern Railway), 68 miles, single and double track (2.5).

(*f*) A later program will include Vienna-Linz-Salzburg (1.1), Amstetten-St. Michael-Villach and Klagenfurt (1.8), St. Valentin-Klein Reifling (.7), Hieflau-Vordenberg (7.1), Linz-Selztal-Bischofshofen

(2,2), and Wels-Passau (.6), giving a total of 669 miles.

Altogether they amount to 1,143 miles, requiring 330 millions kilowatthours per year. Probably, the old Southern Railway line Wien-Graz frontier (183 miles) and Bleiburg-Innichen near the Dolomites (141 miles) will follow, making a total of almost 1,430 miles.

Notwithstanding all other advantages of electric service, the realization of this first program will depend upon first cost and the price of coal.

Austria abounds in unexploited water-power to such a degree that it was possible to examine 315 different sources.

In the choice of system, the Federal Railways have followed the decisions in Switzerland and Germany, and will employ single phase current at a frequency of 16 2/3 cycles per second, with a medium voltage of 15,000 volts on the trolley wire and a transmission voltage of 55,000, or in several cases 110,000 volts, which will be stepped down in a number of substations along the road. The high economy of this system is secured by the simplest overhead construction, economical speed regulation and cheap operation in sub-stations.

The transmission lines are conducted on overhead poles so far as the Arlberg gradients are concerned, elsewhere alongside the roads. Along the pass over the Arlberg mountains up to a height of 2,010 metres, bronze cables are carried on steel towers. As an exceptional case on the Salzkammergut line, the trolley wire is fed direct with 15,000 volts through several feeders without any substation.

The contact wires are built according to well-known types. Height of trolley wires normally 19.2 ft., maximum height 20.1 ft., minimum 15.3 ft. The big 1C+C1 locomotives will pull all trains on gradients up to 3.14 per cent with single traction without an additional locomotive (express trains now need two or three locomotives, freight trains have to run in two halves because of the smoke). There will be an increase of 10 per cent in train weight together with 30 per cent economy in time. The 405 miles of line to be electrified will mean about 220 electric as against 280 steam locomotives.

The narrow cross-sections of the tunnel necessitated narrow collector bows. To avoid short pole distances, and thus to keep down the first cost of the line, it was decided to make a pole distance of 240 ft. and to employ large (68 in.) and narrow (43 in.) collector bows in such a way that while approaching narrow parts of the road (tunnels, etc.) the narrow bow makes contact and when lower than 17 ft. automatically lowers the large bow to avoid risk of damage.

In order to facilitate suburban traffic, there were installed four accumulator trains each consisting of two motor coaches, two trailers and a special tender with a storage battery.

Special attention was paid to the establishing of two thoroughly equipped modern repair shops at Innsburck and Bludenz in connection with the locomotive depots, securing in this way prompt and efficient maintenance quite independent of the manufacturers. It will thereby be possible materially to shorten the time taken in temporary inspection and repair of the rolling stock.

The difficulties arising from the necessity of protecting telegraph and telephone circuits were completely overcome; the main circuits of the railway were all made in insulated cables.

On 22nd of July, 1923, the service was opened on the first short section, Innsbruck-Telfs, and then extended to Landeck. Next March the southern part of the Salzkammergut line will be tried. By the end of 1924 the whole Arlberg line Innsbruck-Bludenz will be open; by August the rest of the Salzkammergut line will be operated exclusively by electric trains.

Electric Traction in Italy

The first trials connected with electric traction which were performed on the Florence-Fiesole electric railway, opened in 1890. Electric traction spread to the tramway lines of a number of Italian towns. In 1900 there existed 124 miles of electric tramways, all running on direct current and constant pressure which was conducted by an overhead wire to the series excited motors, controlled by a series parallel switching arrangements and by switching in resistances.

Later installations, which were designed with great accuracy, ran without a hitch, so that electric traction was considered everywhere to be a success and gave rise to the tendency of applying it to the main railways.

The following three systems were suggested: First, storage batteries; the second suggestion was to adopt the system used for tramways, the only difference consisting in substituting for the trolley wire a third rail as a contact conductor, so as to allow of a better supply of current at high speeds; the third proposal was to adopt rotating field motors with a high tension three-phase line, as had been done in the case of the small Swiss Burgdorf-Turin railway, electrified by the Brown Boveri Company.

Although the Italian Government was not at the time operating the railways, as it does now, it took a great interest in these experiments in view of the utilization of the water power resources of the country.

The direct current system appeared to work regularly; it involved, however, owing to the low tension, considerable installation expenses. As a consequence, the engineers of the railway administration were attracted by the three-phase system, which seemed to be far more suitable for traction purposes on main lines with considerable traffic.

This system was, therefore, extended to most Italian railways, where it is actually applied to an extent of 403 miles in regular service.

Since, however, it has not found any important applications abroad, much controversy has arisen as to whether it was to be adopted in future electrification plants or whether the other two systems preferred in all other countries were to be used, *i.e.*, the single-phase system with high tension on the contact line, and the direct current system.

The objections to the three-phase system are the following:

(*a*) Constant running speed and some difficulty in regulating the speed of trains and, above all, the considerable variation in the demand of power at the central power station, a fact which affects the load factor.

(*b*) A double contact conductor is required with a restriction in the pressure on the line, and some difficulties are experienced in the equipment of switches.

(*c*) The difference in frequency of alternating three-phase current (16 cycles) from that adopted for ordinary industrial purposes (42 and 50 cycles), the drawbacks consisting of the fact that special machines are required at the power houses to generate the current for traction, and that special conductors must be exclusively used for railway service.

(*d*) Sub-stations spacing must necessarily be short so as to avoid large pressure drops which are not admissible in the three-phase system.

As a matter of fact constant speed is not to be objected to from the standpoint of regular running, in view of the fact that locomotives, as will be pointed out subsequently, are now commonly provided with a minimum of four economic (not rheostatic) speeds, which makes it possible to suit the speed to the demand and to the nature of the track.

The necessity of having the double overhead wire did not entail any harmful consequences. It should be mentioned, however, that the pressure was maintained below 3,700 volts.

The difference in frequency adopted in traction problems, as compared with the higher frequency which is preferred for industrial purposes, is of some importance in the appreciation of the kind of system, but it was found that current at 42/50 periods could be used for traction, and current of this frequency will be supplied to a line which is now in course of construction. A scheme is also being studied in connection with the mono-three-phase system.

As to the distance between the sub-stations, experience has shown that drops of pressure up to 30 per cent are admissible with the three-phase system, and this fact gave rise to the tendency now to adopt far longer distances than those applied in the first installations. On the other hand, owing to the higher cost of sub-stations, the use of larger copper sections proved to be comparatively more advantageous.

According to the view of some of our engineers the three-phase system should be preferred in future applications owing to the advantage of dealing with one type of system only.

In Northern Italy, where numerous three-phase traction lines exist, this system will continue to be adopted in future, in Central and Southern Italy, where electric traction is in its infancy, the three-phase system for industrial frequency and the direct current system will be tried.

The first three-phase current locomotives working on the Valtellina lines, where gradients do not exceed 1 in 50, were constructed for speeds of 20 and 40 miles per hour, the motors being coupled in series and parallel respectively. Subsequently, owing to the electrification of the Giovi and Frejus lines with steep gradients (about 1 in 30) and a large freight traffic, the above speeds were reduced to 15.5 and 31 miles per hour respectively.

The locomotives running on level roads are now usually provided with four economic speeds (23, 31, 47, 62 m.p.h.) which are obtained in a fairly simple way by the above parallel and cascade coupling arrangement, in addition to the pole commutation.

One interesting feature of three-phase locomotives is their low specific weight. Thus the most recent types may develop 2,000 kw., their weight being 75 m. tons only, distributed over five axles, a load exceeding 15 m. tons per axle not being permitted on our lines. The tractive effort is limited to 26,500 lb. by the resistance of the couplings.

The economic results of electric traction have given rise to considerable discussion in Italy owing to the great dfficulty in appreciating them. A comparison with steam traction has shown that, as a rule, the cost of fixed plants for electric traction is high, so that substitution will only prove profitable in the cases of lines with steep gradients and a considerable amount of traffic in addition to a low cost of power. It is difficult to state the cost of plants under the present circumstances, as most of them were erected before the war. Fair average figures cannot be given either, as the expenditure varies for each individual case, according to the type of line (double or single track), the number of stations relative to the length of the line and finally according to the number of tunnels, and the length of the main lines required. According to pre-war estimations, electrification was found to be profitable on those lines which only showed an average yearly consumption of 675 tons of coal per mile.

This formula, although the figures from which it was deduced differ greatly from the actual ones, may still hold if we consider that the cost of coal and that of plant increased simultaneously and almost at the same rate.

Electrification of Railways in the Dutch East Indies

The first plans date as far back as 1911 and were drawn up by the well-known engineer Damme. The economic conditions then existing in the country did not permit the carrying out of these plans. With no thought being given to the coming congestion, electrification in those days was still regarded as a luxury, and public opinion in consequence was against the granting of credit for such innovations, although comfort in the tropics is a factor well worth consideration.

It was soon seen that the economy of electrification would first have to be demonstrated and that this could not be done before water power had been developed in Java. Careful estimation of costs showed that a voltage of 1,500 volts for the railways in Java would be adequate, and that a choice of 2,400 or 3,000 volts would result in an increase of 30 per cent on the initial cost of rolling stock, without, however, decreasing in the same ratio the costs of the overhead lines or sub-stations; thus a reduction on initial outlay expenditure was possible, with increased operating safety with the lower voltage.

By 1921 all the plans had been prepared and demands for tenders sent to various factories.

Unfortunately, at this time opposition arose in the Dutch Parliament against electrification. This opposition caused a big setback to the carrying out of the plans and resulted in their being temporarily cut down. It has been decided for the present only to electrify the railways round Batavia.

Power Stations

The current is to be supplied by two water power stations, erected by the Department of Water Power and Electricity. The first is the Tjitjatih station, now called Oebroeg, which gets water from the Tjitjatih and some other streams. The second power station is the Tjianten station, now called Kratjak works. It lies 10.5 miles from Buitenzorg. Here also most of the waterworks are

completed; the necessary engines, however, have not yet been ordered.

The Tjitjatih power station is adapted for a constant water capacity of 10 cu. m. per second, equal to an average of 7,500 hp. during twenty-four hours, measured on the turbine axles.

At present two sets of 7,500 h.p. are being erected. By means of accumulation it is possible to increase the peak output quite considerably. Should the Tjianten power station be completed, the average power production of both works would be increased by 10,000 h.p. during twenty-four hours and the peak load by a good 30,000 h.p. These two power stations together, therefore, will make possible the electrification of a great number of lines.

Transmission Lines

The current which will be generated from our power stations is to be high-tension three-phase current of approximately 70,000 volts and will be transmitted by overhead wires to the consuming centers. These high tension transmission lines consist of a double set of wires, each set containing three wires. These wires are hung on iron towers standing 960 to 1,280 ft. apart. By this means it is possible to overcome all obstacles, such as ravines, etc.

Sub-stations

The arrangement for the sub-stations is as follows:

The three-phase high-tension current of 70,000 volts is stepped down by means of static transformers to 6,000 volts three-phase current.

The 6,000 volts current is transmitted to the State Railways, which thereafter dispose of it. In the engine house the 6,000 volts three-phase current is transformed down to 1,500 volts direct current. This takes place in rotary transformers or motor-generators, of which two sets are to be erected in each sub-station. Of these, each is of a continuous capacity of 1,500 kw. d.c. The current from here is conducted through control and safety apparatus and finally after passing underground is transmitted to the overhead railway lines.

Contact Wires

The overhead constructions are to be delivered complete by the Siemens Schuckertwerke, who are well known for this kind of work. Original designs are being followed, namely, as contact wire, a double line of 107 sq. mm. hard copper hung from a special suspension wire. In consideration of the fact that the copper section of 2 x 107 sq. mm. is not sufficient to conduct the current, it is necessary to build a special feeder cable and for this purpose we have decided to use a suspension, which instead of 70 sq. mm. steel, will be made of hard copper, but of a diameter of 150 sq. mm. In this manner we hope to have less risk of damage to the material by the gases coming from steam trains whenever they have to pass, and also from our moist sea atmosphere. Each track will, therefore, be fed by a total diameter of approximately 360 sq. mm. Current of 2,000 amperes can with safety be carried by this.

In certain cases where an exceptionally heavy current consumption is to be expected, as, for instance, on mountain lines or where many trains are starting at the same time, extra feeder cables of 100 sq. mm. will be fixed upon the iron girders of the super-structures.

Rolling Stock

The arrangement of the motor coaches is to be based on the American system. These trains will with ease be able to attain a speed of 45 m.p.h. and when necessary even 55 m.p.h.

For this purpose the motor coaches will be fitted with four motors each of 125 h.p. one hour rating and for 750 volts. The motors will therefore be used two by two in series or parallel connection. The motor coach will be fitted with two pantographs.

Locomotives

As previously stated, regular service with short intervals between each train, will be kept up in Batavia. Locomotives are, however, also necessary for through trains. Two of these have been ordered for the present from the Werkspoor-Westinghouse, the principal characteristics sought being a combination of great hauling powers, limited speed and great simplicity.

The Financial Aspects of Main Line Electrification in Great Britain

By Sir Philip Dawson

The benefits to be derived from the electrification of purely suburban systems are well known, and it is not proposed to deal with them specifically in this paper. The benefits to be derived from the electrification of complete sections of a railway are not realized in this country as much as they should be, and there is a popular belief that only where water power is available, or in the case of mountain lines, can the complete electrification of a railway system or of a considerable portion of it be justified. It is with the object of disproving any such idea that the following paper has been prepared.

It is hardly necessary to say that as far as main line electrification is concerned, we have nothing to show, while on the Continent of Europe, South Africa, New Zealand, Japan, the United States and South America, very considerable progress has been made in this direction.

It is not only from the point of view of the railways or of the traveling public that electrification will be of immense advantage. Electrification on a large scale will largely conduce to an abundant and cheap supply of electricity not only to industrial areas, but also to many of the rural areas which under ordinary circumstances would not obtain it.

It will in many cases enable coal to be utilized at or near the pit head of a quality much of which now is more or less useless. It will largely reduce the smoke nuisance, and enable the railways to utilize for building purposes most valuable sites in the center of many of our large towns by covering in their stations and the railway tracks immediately adjoining them, as has been done in the case of the Pennsylvania and New York Central Terminal stations in New York.

The electrification of the whole of the lines in and out of Liverpool street station would enable buildings to be erected over all the lines inside and immediately outside that station, thus rendering available for building purposes a site which has been valued at £5,000,000. There are many other similar cases to be found in Great Britain, where the value of the site which electrification renders

suitable for building purposes, will largely cover the capital required for carrying out the electrification.*

Power for Transport—Railroad Electrification

By Prof. Dugald C. Jackson
Massachusetts Institute of Technology

The large area of the United States, the relatively low density of population in most of the country, and the great distances between large cities and between areas of production and consumption have caused American railroads to develop differently from western European railroads; the direction of development in America having been for long hauls with notably heavy trains and powerful locomotives, associated with the utmost practicable utilization of track facilities. The electrification problems therefore are different.

These conditions apply to Canada also, as well as to the United States.

Electrification offers opportunities in America for increasing capacity of permanent facilities beyond the limitations imposed by steam motive power even of the most modern types, and electric installations for railroad traction have slowly increased along a natural economic route, more particularly to relieve congestion at tunnels and at terminals and to handle heavy traffic over severe grades or to increase track capacity for general service on main line divisions, where the conditions had grown beyond the scope of improved steam motive power. This progress is contributing to the advantage alike of railroad patrons, the general public, and the railroads themselves. In these installations the electric motor has eminently proved its merit for the purpose, and the economies, increased capacity of trackage, acceleration of train movement, prevention of congestion, and other advantages from electrifications suitably installed have been demonstrated. Approximately 700,000,000 kilowatt hours are now used per annum for hauling trains in the electrified zones.

The cramped financial condition of various principal railroads, caused by heavy taxation and agitation for lower freight charges, is preventing them from realizing the advantages of electrification in many additional situations where its installation would be serviceable. Nevertheless, the use of electrical power for railroad traction is steadily increasing and it will be greatly extended in the future. It is estimated in this paper that the prospective early electric power needs of the American railroads, for those zones of trackage that are approaching traffic saturation when using steam motive power of improved types, and which will secure relief by electrification, are of the magnitude of 5,000,000 kilowatts of generating capacity and an energy absorption per annum of ten billion (ten thousand million) kilowatt hours. While many railroads operating electrifications generate their own electrical power, the tendency is to interconnect with large existing power systems (whether steam, electric or hydro-electric) where such are available, for the purpose of purchasing power; thereby securing economy, dependability and flexibility in the power supply, and at the same time conserving expenditure of railroad capital in order that it may be reserved for investment in transportation plant *per se*.

The prospective power requirements thus estimated make a large individual aggregate, but the well developed American electrical power industry can readily meet the need.

*The greater part of Sir Philip's paper consists of the outline of a project for electrifying the L. B. & S. C. R. Railway in England.

Field Coil Maintenance for Pyle-National Generators

By R. E. Rice
Electrical Supervisor, N. Y. C. R. R.

I have read with great interest and profit the several articles published in *Railway Electrical Engineer* relative to maintenance of electric headlight equipment, and would like to add something to these excellent articles, covering the maintenance of field coils for generators of the Pyle-National, bi-polar, Lundell type.

Experience has taught us that heat, oil and vibration are the principal factors causing field coil failures. Knowing this, it would seem the logical procedure to build a

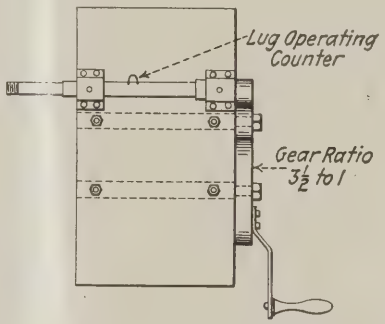


Fig. 1 General Arrangement of Winding Machine

coil that will stand more heat, prevent as far as possible the entrance of oil, and protect the coil against the effects of vibration. This, we believe, we have in a measure accomplished.

We have made a hand-operated winding machine of simple design with a gear ratio of 3½ to 1 with tapered spindle to fit the brass bushings in the coil forms. These forms are made of cherry, turned on a wood lathe. The slots for the ties were cut on a band saw. No dimensions for the machine or forms are given as the dimensions for

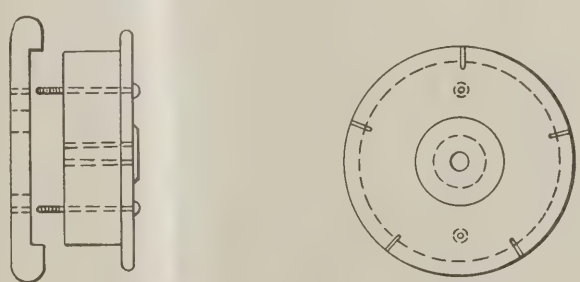


Fig. 2 Form for Winding Shunt Coil

the forms can be secured by measuring the coils, and, without doubt, each reader desiring to construct a machine would want to make it in accordance with his particular ideas; some, no doubt, would want to adapt existing coil winding machines. These sketches simply show how it is done at our shop. Fig. 1 shows a general arrangement of the machine. Fig. 2 shows the arrangement of the shunt coil form, and Fig. 3 is that of the series coil.

First, we will consider the manufacture of the shunt coil. No. 22 A. W. G. C. E. wire is used. The fibre rings are purchased. The coil covering is cut from 1/32 in. sheet fibre on a square shears. The inside covering is placed on the form and held in place by the fibre rings when the cap or outer flange is secured in place with the two

bolts with wing nuts. One layer is wound and given a coat of air drying compound, then each two succeeding layers are heavily coated. When coil is finished, it is then tied and allowed to dry for a time, after which the outside is given several additional coats. The outer covering is then applied and taped with linen tape. The ties are cut and removed from the coil as the taping proceeds, leaving the coil smooth on the inside for the insertion of the series coil. It is then given three coats of compound and allowed to air dry.

The series coil is made of No. 9 A. W. G. D. C. C. wire in the same manner with the exception that each layer is

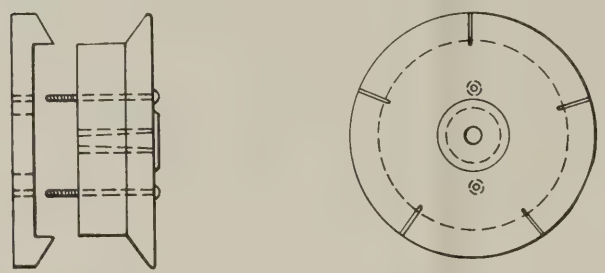


Fig. 3 Form for Winding Series Coils

heavily coated with compound. The last turn is tied with armature twine (which has been placed under the last course) to prevent it from becoming loose until the compound sets.

After the coils have become dry they are assembled and taped with 1 in. cotton webbing and on that portion of the series coil which comes in contact with the pole pieces, a piece of 1/64 in. sheet fibre is inserted under the webbing. This prevents grounding of the coil, which occurs frequently. The assembled coil is then given three coats

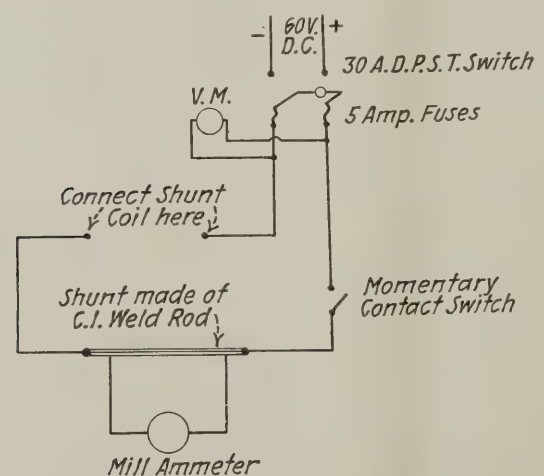


Fig. 4 Wiring Diagram of Circuit Used for Testing Shunt Coils

of compound and allowed to air dry. If it is necessary to place the coils in service before they have had time to air dry, they can be baked at a temperature of 120 degrees Fahrenheit for 12 or 15 hours.

Up to the present time we have used the solid wire terminals on the series coil. However, we are contemplating the use of flexible terminals connected to the coil by means of a soldered sleeve.

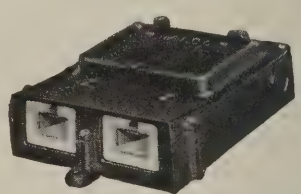
From performance records obtained from coils made in above manner, we find they will stand a higher temperature due to the use of cotton enamel wire and the compound. The compound serves four purposes: that of a heat conductor, an oil resistant, stays the coil against the effects of vibration and adds to the dielectric strength of the insulation.

Fig. 4 shows the circuit of the apparatus we have made for testing the shunt coil and is essentially as follows: The coil is placed directly across a 60-volt d. c. circuit with a shunt made from a piece of cast iron welding rod in series with the coil. A milli-ammeter is connected to the shunt and the terminals adjusted so that the meter will read 25 mill-amps. with a new coil in circuit. Then the terminals of the meter fixed at that point. A momentary contact switch is used to switch the coil in circuit and this switch makes it impossible to leave the coil in circuit after the test is completed. If, on testing a coil, it reads 30 mill-amps. or more the coil is discarded, as in every case we find the insulation badly carbonized. A low reading ammeter, with self-contained shunt can be used in place of the arrangement described if the instrument is graduated in dimensions of 1/10th or more.

Our experience has been, that coils made and tested in this or similar manner will materially reduce the number of headlight failures and will not increase the cost of maintenance.

Receptacles with Grounding Contacts

The Central Electric Company of Chicago has recently added to its line of Ralco fittings a number of receptacles and plugs with grounding contacts. These receptacles and



Twin Fused Receptacle With Grounding Contacts

plugs permit the fulfillment of code rules for Browning motors. No. 16 G twin fused receptacle of this new line is shown in the illustration.

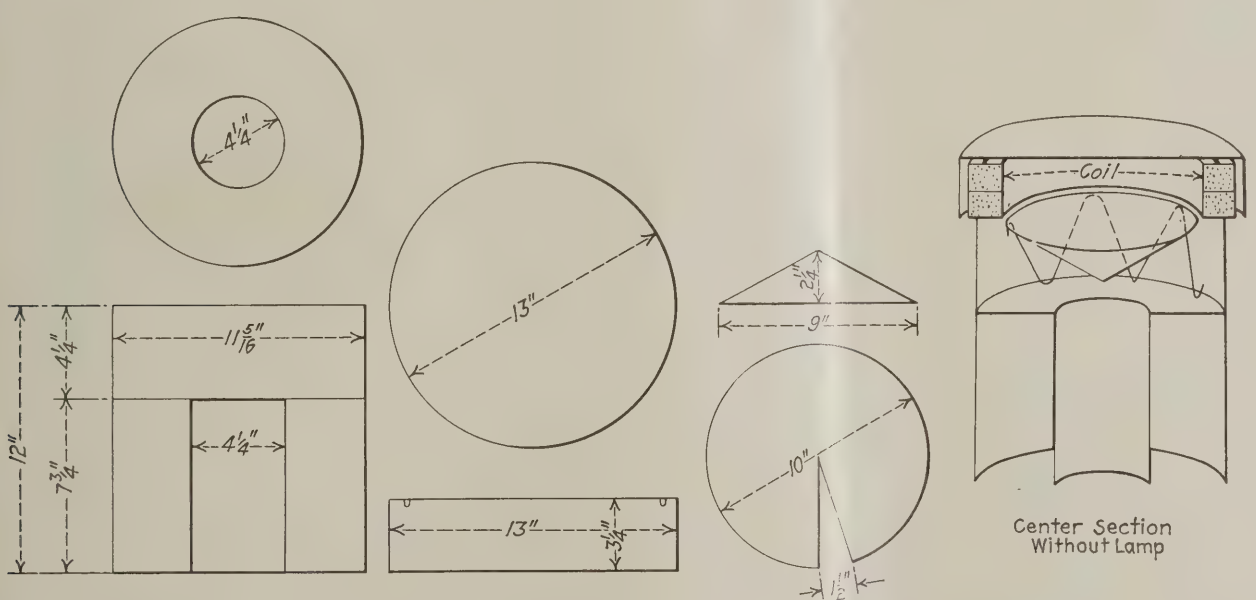
A Typical Country Station, Italian Railways

A Cheap and Efficient Oven for Baking Field Coils and Armatures

By James C. Moore
Chicago, Rock Island & Pacific Railway Company
Eldon, Mo.

In an effort to save sending Pyle-National Type "E" field coils to the back shop for repairs of a minor nature and to insure the proper insulation of the coils and armatures repaired locally, it was found necessary to construct an oven in which they could be dried thoroughly before and after the insulating material and varnish was applied. An oven which is giving splendid results was constructed as follows out of a discarded varnish can of the five-gallon variety, some old sheet metal car roofing and a small amount of tin.

The top was cut out of the varnish can so as to leave the top seam with its rounded edge, and to eliminate all sharp points and edges. The lower part of the can was cut away so as to leave it twelve inches long, and the shape changed to a circular or drum, with a diameter of 11 5/16 in. A spacer, which also serves as a reenforcement, was made out of the ex-car roofing as well as a smaller drum. The spacer is a flat piece of the roofing, cut to fit inside of the large drum and over the smaller one. The small drum is 7¾ in. long with a diameter of 4¼ in., and is soldered to the spacer at one end.. The spacer is soldered in the larger drum at a distance of 4¼ in. from the top with the smaller drum on the lower side. This whole arrangement was placed on four old friction tape cans and a 200-watt lamp in a keyless socket was placed inside the smaller drum. In using with a field coil, a cone was made by cutting a piece of tin ten inches in diameter and then taking out a segment that measured an inch and a half on the edge of the piece and then lapping it a like amount. The result was a cone nine inches by 2¼ in. high.



Dimensional Sketches of Baking Oven

This cone as well as the small drum was riveted, as the most heat is at these points. The cone is supported, point down, by a framework of copper wire resting on the spacer, so as to leave a space of about a half inch between the top of the cone and the lower edge of the coil. Over the coil is placed a cover made by soldering a rim 3¼ in. wide to a round piece of tin 13 in. in diameter. On the under side of this cover three small U-shaped pieces of wire are soldered so as to hold it about half an ineh above the coil, on which it rests. The oven was constructed with the idea of leaving an air space all the way around the coil that the hot air from the lamp, which is inside, would have to follow before escaping. The construction

also provides for a continual draft that will help to dry out the coil by carrying the dampness with it.

For treating armatures, the cone and top cover are left off and the armature is placed directly over the small drum with the hole in the center of the commutator covered with a piece of metal or wood.

Trivial Dangers

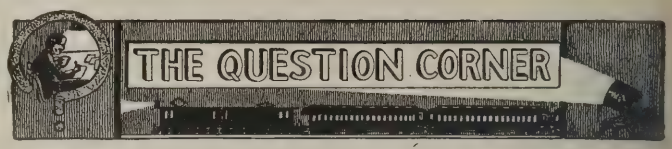
The dangers lurking about your job are known best by yourself. Because of your familiarity with your job don't feel that the dangers are trivial—mention them to others who place themselves in danger. Your suggestion to another may safeguard you in a moment of carelessness later on. Your family wants you to come home tonight, the boss expects to see you back at work in the morning, and the hospital doctors and nurses don't want to see you or have you around.

It Isn't Your Railroad—It's You

If you want to work on the railroad, the kind of a railroad
you like,
You needn't slip your clothes in a grip and start on a long,
long hike.
You'll find elsewhere what you left behind, for there's
nothing that's really new.
It's a knock at yourself when you knock your railroad,
It isn't your railroad—it's you.
Real railroads are not made by men afraid lest somebody
else gets ahead.
When everyone works and nobody shirks you can raise a
railroad from the dead.
And if while you make, your personal stake,
Your neighbor can make one, too,
Your railroad will be what you want to see,
It isn't your railroad—it's you.

Some Folks We Know

If there's anything we do despise; it is a bunch of helpless guys, who park themselves away; until the boss comes on the scene, and beats a program in each bean, of *what* to do that day . . . We've also seen the useless cuss, who stalks about with little fuss, and pulls a grand stand stall: for hours he will mutely stand, 'till you put *something* in his hand; so he can hit the ball . . . There are others with an alibi, with sixteen handy reasons why, the work has been delayed: for *some one* they must always wait: they tell a story slick and straight, and arguments evade . . . . And there's the bird who left alone, will do the job he calls his own: then loaf for half a day: he can enjoy this sweet repose, with other work beneath his nose, because he *thinks* that way . . . If those within the rank and file, could work and duty reconcile, by changing their belief: so when they finished one small chore, they'd look about and find some more: the world would have less grief . . . Don't feel that man's initative, was so good it couldn't live, (although the good die young), because if records are but searched; they'll show the boob who had it perched, on the ladder's top-most rung . . . It's not a Dodo now extinct, nor even with great effort linked; so please don't be misled: the ones who feel that sweet caress, which flows to those who win success, have simply *used their head.*



Answers to Questions

1. *Can you tell me which country has the most powerful electric and steam locomotives and the tonnage they pull?*

2. *What is meant by a storage battery being in a "starving" condition?*

Power of Locomotives

1. The most powerful steam locomotive in the world today is the "Triplex" which is in service on the Erie Railroad. The total weight of the engine and tender in working order is 853,000 lb. and the tractive effort compound is 160,000 lb. This locomotive is used in pusher service and is capable of handling approximately two-thirds of a 6,000 ton train on a 1.2 per cent grade 8 or 9 miles long. It should be considered that this locomotive is used in highly special service and its limited boiler capacity would scarcely warrant its use on a longer grade.

If the Triplex is discounted, then the Virginian 2-10-10-2 Mallet is the most powerful steam locomotive. The weight of the engine and tender in working order is 898,-300 lb., tractive effort compound 147,200 lb., tractive effort simple 176,600 lb. Trains weighing 5,850 tons, the equivalent of 78 cars having an average gross weight of 75 tons each are hauled between Elmore and Clarks Gap by a 2-8-8-2 Mallet road engine and one of the 2-10-10-2 Mallet engines as pushers. The distance from Elmore to Clarks Gap is about 14 miles and there is a grade over the last 11½ miles of 2.07 per cent with maximum compensated curves of 12 degrees. For the first 2½ miles the grade is .5 per cent. The speed of the train is about 7 miles per hour.

The electric locomotives now being built for the Virginian will be the most powerful locomotives in the world, electric or steam. They will consist of three motive power units under the control of one engineman. The total weight of each locomotive will be 1,200,000 lb., a continuous tractive effort of 135,000 lb. and the maximum tractive effort 277,000 lb. Trains of 6,000 tons will be hauled from Elmore to Clarks Gap with one road locomotive and one pusher at 14 miles an hour.

"Starved" Storage Batteries

2. If the conditions under which a battery is used are such that the battery regularly receives less current than it requires, and it therefore remains constantly in a discharged condition, it may be said to be "starved." In this condition the sulphate to which a large part of the active material is kept reduced will gradually harden into the non-porous form. This removes the usefulness of these portions of the active material until the battery is given a reforming charge. There is also a tendency for this form of sulphate to extend itself gradually into even those portions of the plates which are kept charged so that the plates are soon sulphated and useless until reformed.

Questions for September

1. *Is there any limit to the thickness of metal that can be welded by the arc welding process?*

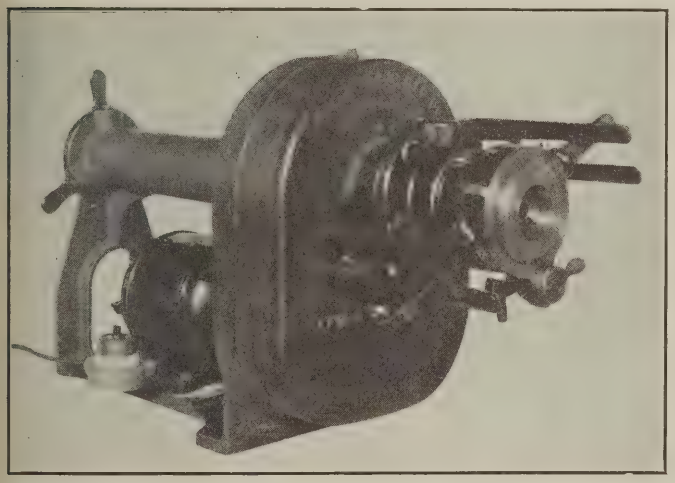
2. *What is Lenz's Law of Induced Currents?*

NEW DEVICES

Power Driven Pipe Threading Machine for Small Work

A simple and compact power driven pipe threading machine has been designed by the Oster Manufacturing Company, Cleveland, Ohio, which will thread all sizes of pipe from ¼ in. to 2 in., inclusive. It has three desirable qualifications: Portability, light weight and capacity for small work in railroad shops and terminals.

The machine is driven by a 1/3-hp. motor geared to the



The Motor of this Portable Threading Machine Runs from an Electric Light Socket Which Eliminates Extra Wiring

driving arm, which furnishes ample power to thread all sizes within the range of the machine. The motor is run from an ordinary light socket, which eliminates the necessity of installing extra wiring. The driving arm maintains a zero load speed of 9 r.p.m. and approximately 8 r.p.m. under a load. The motor will drive the regular No. 104½ Oster Bull-Dog die stock, the dimensions of which are 2 ft. 11 in. long, 1 ft. 2 in. wide and 1 ft. 8 in. high. The machine, complete with motor, weighs slightly over 200 lb., which makes it convenient for two men to handle.

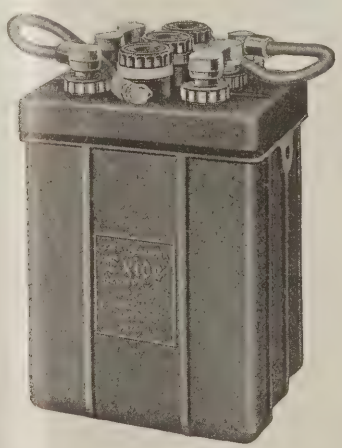
The tool is equipped with a built-in scroll chuck and auxiliary centering guide which eliminates the necessity of an extra vise. The chuck and the guide are self-centerng and self-locking. The gears are completely enclosed and run in oil, and operate with very little noise or wear. The driving arms, which are necessarily extra strong, are of malleable iron. The chuck jaws and guides are drop forged steel and casehardened.

The machine is simple to operate. The cutter is placed on the pipe in much the same manner as it is when about to thread by hand. The handle rests against one of the driving arms and the machine revolves it. The only attention the operator need give the machine is to tighten it on every revolution.

Light Weight Storage Battery for Rail Motor Inspection Cars

A storage battery for furnishing ignition and lighting on rail motor inspection cars has been developed and is offered by The Electric Storage Battery Co., Philadelphia manufacturers of Exide Batteries.

This battery is offered to meet the demand for a current for lighting and ignition on rail motor inspection cars. It will furnish bright lights for the headlights and for the inspection lights, and at the same time furnish ignition. It



Rail Motor Car Battery

can be charged over night with a low cost rectifier thus making its maintenance cost low.

The battery weighs only eight and three-quarter pounds, three cells, six volts, with a rated capacity of 11 ampere hours for intermittent lighting. Its length is 3½ in., width 4½ in. and height 6¾ in. Built as one unit with three-compartment hard rubber case specially rein-

forced, this battery is designed to withstand the demands of railroad service.

The thick, heavy plates and wood-and-rubber separators insure longer life.

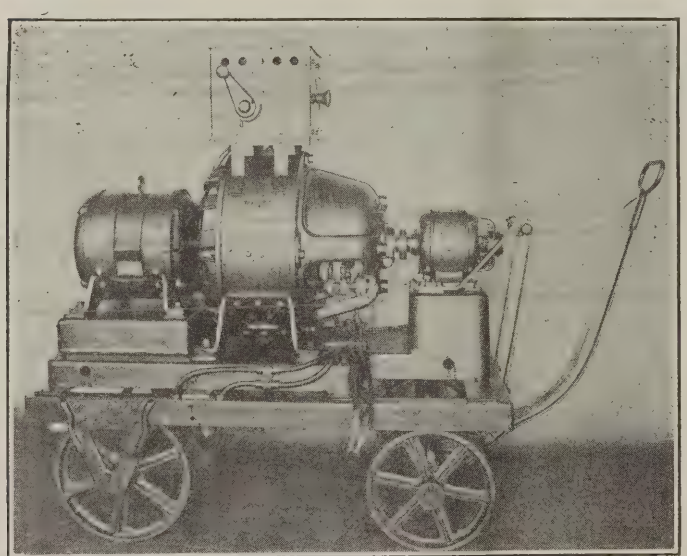
The filling plug requires only a quarter turn to the right, which locks it securely in place and makes it impossible for the solution to splash out over the battery and case. The plug is just as easily removed.

Westinghouse Welding Set

A one-man portable arc welding set has been developed by the Westinghouse Electric & Manufacturing Company which is compact, extremely rugged and has a wide range of current control.

It consists essentially of three direct-connected machines and a control box all mounted centrally on a four-wheel truck. It has a 10 h. p. 200/440-volt, three-phase induction motor running at 1,740 r. p. m. There is also a 5 kw., 25-volt, 200-amp. welding generator; the exciter is a 1/2 kw. compound wound 125-volt direct current generator. The current rating of the exciter is four amperes while the maximum current it is required to furnish is 2 amperes. The machine is therefore twice as large as necessary and this is done to provide a small machine which is as rugged and of as good design as the larger ones.

The main shaft of the set runs in ball bearings and is 3 in. in diameter. This large size is used to prevent possible injury to the machine by the shock and strain of



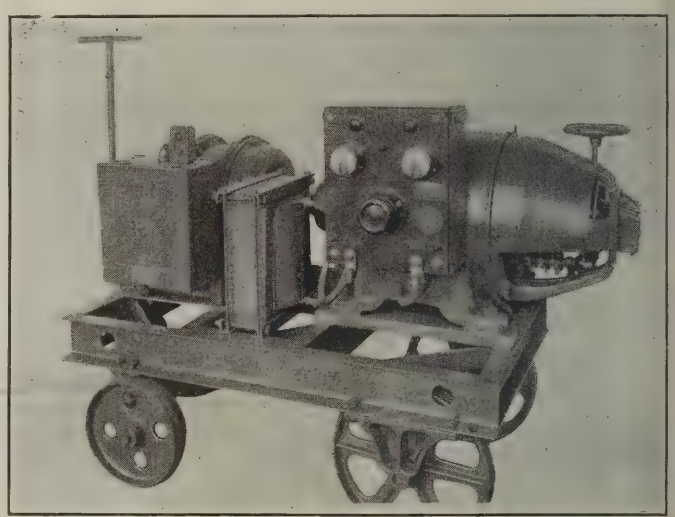
The Welding Set Is Ruggedly Built and Has a Wide Range of Current Control

suddenly applied loads. The exciter is also a ball bearing machine connected to the main shaft by a flexible coupling. The control panel is totally enclosed and mounted on top of the generator where it is easily accessible and not liable to injury. It contains the motor starter, the welding current control rheostat and a voltmeter and ammeter to show the generator output. The current output of the generator can be varied by the rheostat in 61 steps from 60 to 300 amperes. Regulation is inherent. The open circuit voltage is 70 volts maximum. The one-hour current rating of the generator is 200 amp. with a 50 deg. temperature rise while the continuous rating is 186 amp. Unusually good ventilation is principally responsible for the small difference. Cast cover plates are used to protect the armature and brush rigging and all steel parts of the brush rigging are sherardized to prevent rusting.

Extra leads are brought out from the motor so that it can be used on either 220 or 440-volt circuits. The complete outfit including the truck weighs 1,850 lb.

Portable Arc Welder

A new portable arc welder, embodying distinctive features of economy, simplicity, adaptability and dependability, has been placed on the market by the General Electric Co. This unit is said by the manufacturer to be designed to insure smooth and rapid deposition of metal with thorough penetration. It will deliver continuous power and permit rapid production, both with high current and large electrodes, as well as with low current and small electrodes.



Arc Welding Generator Driven by a 10 H. P. Motor

This welder is a two-unit set, consisting of a motor and a generator. The generator is self-excited, thereby eliminating the necessity of a separate exciter. Regulation of current is accomplished by turning a handwheel on the generator. A self-adjusting, stabilizing reactor is provided, which automatically steadies the arc under all welding conditions.

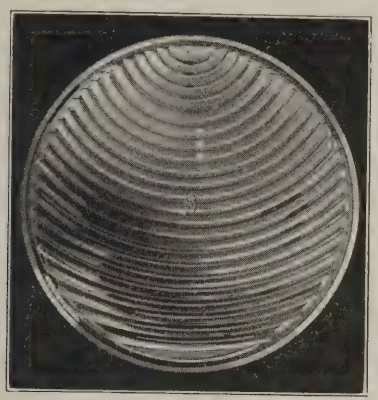
The welder can be used with any of the commercial sizes of metallic electrodes from 1/16 in. to ¼ in. in diameter. Generator voltage can be adjusted to suit the character of the work. High voltage for complete penetration on heavy work, and low voltage to prevent burning through on light work, are thus secured at will. Any value of current between 75 and 300 amperes can be obtained in a large number of steps between these limits.

The generator is a two-pole, self-excited, constant energy, single-operator machine with a dual magnetic circuit designed to operate at 60 volts, open circuit, and from 20 to 25 volts under load. It is rated 200 amperes for continous service, 250 amperes for one hour and 300 amperes for short periods. The motor is a standard G. E. 10 horsepower unit. The complete set has three bearings, the two units being close-coupled by a solid flange coupling. All parts, including generator, motor, generator

control panel, motor starter and stabilizing reactor, are mounted on a welded structural steel base of rigid construction and light weight.

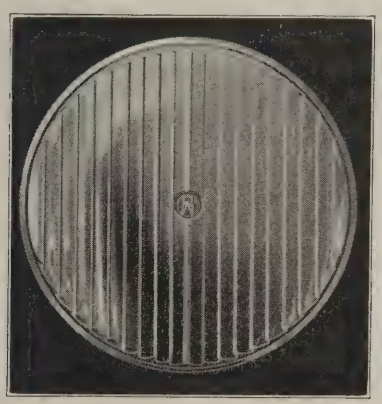
Headlight Lenses and Floodlight for Yard Lighting

Among the products of the Pyle-National Company, Inc., Chicago, are two new lenses for locomotive headlights and a new model floodlight for yard lighting work.



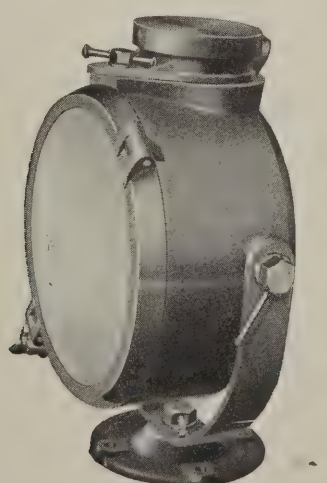
The No. 1442-F Headlight Lens Eliminates the Blinding Effect of Plain Lenses

The No. 1442-F lens is designed for switch engine use.



The No. 1442-S Headlight Lens Spreads the Light Over a Large Area in a Beam of Rectangular Section

It eliminates the glare and minimizes the danger to switchmen working in front of the locomotive, so that it is possible for them to look directly into the headlight without any of the blinding effect encountered with the ordinary headlights, and making it possible for them to see the footboard of the locomotive. The No. 1442-S is also employed for switching locomotives. This lens gives a rectangular beam of great spread, which is capable of covering a large area.



The Pyle-National Floodlight for Yard Lighting

The floodlight is made with a body of aluminum-alloy or gray iron, finished in battleship gray or black enamel. All fittings are rustproof plated wrought iron or steel. This light is used with a standard 300 or 500 watt lamp and throws an evenly distributed floodlight of high intensity. The reflector is of non-glare, silver-plated copper or glass.

The mounting is of the swivel base, pilot-house control type. This light occupies a space 9¾ in. by 14¼ in. by 19 in. and weighs 30 lb.

Three Re-Designed Fittings

The Bryant Electric Company has recently re-designed a number of its products. One of these is an outlet box receptacle known as No. 59107 and has been changed so that the boss on the back will fit any holes 1 11/16 in. in diameter. It is also equipped with 6 in. leads of No. 14 B. & S. stranded rubber covered wire; one wire which is black is connected to the phosphor bronze center contact and the other wire which is white is connected to the screw shell thus identifying the terminals. The body is white glazed porcelain with shade holder grooves to receive any standard weather-proof or clamp type of shade holder taking 2¼ or 3¼ in. shades. The rating of the receptacle is 600 watts, 600 volts.

Outlet Box Receptacle

Spartanette Attachment Plug

Keyless Socket Body

Another Bryant fitting which has been re-designed and improved is the attachment plug known as the Spartanette. The body and cap are made of "gummon" composition. The cap has been strengthened by increasing the thickness of the walls. The jack contacts on the cap are held by spun-over rivets; there are no screws to loosen. The appearance of the re-designed plug is an improvement over the former design and the cord hole is elongated to take the parallel conductor cords used for portable devices. There is plenty of room in the cap for underwriters strain relief knot.

The third re-designed fixture is known as the Wrinklet keyless socket body. The terminals to which the wires are attached have been altered so that bigger binding screws can be used. This change permits the use of a stronger porcelain base and allows the terminals to be more firmly supported. In addition to these changes, the terminal connected to the screw shell of the socket is now nickel plated to conform to the system of identifying terminals adopted by the socket manufacturers.

General News Section

The El Paso & South Western will install the Bulla system of automatic train control and is now building the necessary equipment in its shops at El Paso, Texas.

The Gibb Instrument Company, Bay City, Mich., has appointed F. J. DeLima as agent for the sale of its line of electric welding and electric heating machines in the Dominion of Canada. Mr. DeLima's headquarters are in the Keefer Bldg., Montreal.

The Interstate Commerce Commission has denied the petition of the Reading Company that it be exempted from the operation of the automatic train control order and also a petition of the Galveston, Harrisburg & San Antonio for a modification of the order to permit it to make its installation on a portion of a division.

The pilot trucks of all five of the locomotives of the Alberta & Great Waterways, a Canadian road, have been equipped with steam pipes which eject steam under pressure to clear the rails of caterpillars. The swarms of caterpillars had crossed the tracks in such numbers that, when crushed, they made the rails slippery, rendering the operation of trains unsafe and at times impossible.

A cumulative index-digest of decisions of the United States Railroad Labor Board issued before July 1, 1923, has been published by the government printing office at Washington. The volume includes all regulations of the Railroad Labor Board, court and administrative decisions, and regulations of the Interstate Commerce Commission in respect to Title III of the Transportation Act, 1920.

The Richmond, Fredericksburg & Potomac has awarded a contract to the Union Switch & Signal Company for the installation of its two-speed continuous inductive automatic train control system on its line between Washington, D. C., and Richmond, Va., comprising approximately 100 miles of double-track line. A total of 66 locomotives are to be equipped for train control operation.

The Pennsylvania now uses 40 motor trucks in the movement of local freight over routes formerly served by regular local freight trains. The length of these daily motor truck routes is now 1,412 miles, more than double the mileage operated last spring. Among the routes recently established (with the length of each in miles) are the following: Trenton, N. J., to Lambertville, 16; Trenton, N. J., to Linden, 49; Uniontown, Pa., to Ruffsdale, 38; Toms River, N. J., to Sea Girt, 23; Sea Girt, N. J., to South Amboy, 33; Sea Girt, N. J., to Jamesburg, 28; Philadelphia, Walnut street, to Trenton via Pemberton, 78; Enon, O., to Alliance, 53; Trenton, N. J., to Phillipsburg, 51.

The United States Civil Service Commission announces the following open competitive examination for junior engineer. The examination will be held throughout the country on October 8. It is to fill vacancies in various branches of the Government service at an entrance salary of $1,860 a year. Advancement in pay may be made without change in assignment up to $2,400 a year. For appointment outside of Washington, D. C., it is probable that this same rate of pay may be applicable, but if not, the entrance salary will be from $1,500 to $2,000 a year. Examination will be given in the optional subjects of electrical engineering and radio engineering. Full information and application blanks may be obtained from the United States Civil Service Commission, Washington, D. C., or the secretary of the board of U. S. civil-service examiners at the post office or customhouse in any city.

Chicago Terminal Plans

Plans for the consolidation of the LaSalle street, the Dearborn street and the Grand Central passenger stations in Chicago are taking definite form and an announcement of the program agreed upon by the committee of presidents of the roads involved is expected soon. According to Mayor Dever, of Chicago, the proposed terminal will be similar to the Grand Central terminal in New York, in that it will be surrounded by two-level streets and will have depressed tracks over which office buildings will be erected. The Committee on Railroad Terminals of the Chicago city council expects to start next month on a tour of eastern passenger stations.

Association of Railway Electrical Engineers' Annual Convention

The fifteenth anniversary convention of Association of Railway Electrical Engineers will be held at the Hotel LaSalle, Chicago, Ill., October 21 to 24, inclusive.

The meeting will start at 9:30 A. M. Tuesday morning, October 21, but it is more than likely that the Exhibit Halls will be open and ready for inspection Monday night, October 20. The entire nineteenth floor, both the Grand Ball Room and the Red Room, will be given up to exhibits, and the Manufacturers' Association promises a very elaborate display of the latest developments in electrical apparatus used by steam railways.

The association meetings, beginning Tuesday morning, will be held each morning in the East Room on the mezzanine floor. The afternoon of each day is reserved for the purpose of inspecting the exhibits and becoming acquainted with latest developments.

Special entertainment features in connection with the convention are being arranged.

Wednesday evening, October 22, Carnival Dance in the Louis Fourteenth Room on the main floor.

Thursday afternoon, October 23, Ladies' Card Party in the East Room on the mezzanine floor.

Thursday evening, October 23, theatre party for ladies and gentlemen.

Friday evening, October 24, dinner dance and entertainment, Grand Ball Room on nineteenth floor.

This being the Fifteenth Anniversary Convention there will be many special features in celebration thereof. The committee reports will be printed in the *Railway Electrical Engineer* and mailed you so as to be in your hands before leaving for the convention.

Swiss Railway Electrification Progresses

Switzerland's progress in the electrification of the Federal Railways is illustrated by the completion of the electrification work on the line from Chiasso at the Italian frontier to Basel at the German-French frontiers. The last section of this line, from Olten to Basel, was formally opened to electric traction on June 1, 1924, thereby completing a continued stretch of railway line with electric traction, crossing the entire country and having a total length of 197½ miles. The completion of this line brings the total electrified trackage to 315 miles including the Simplon tunnel line from Brigue to Iselle, 13 miles long, which was opened in 1906.

The program of electrification of the Federal Railways in Switzerland is a result of the severe economic conditions which existed during the war, when the Swiss people were dependent on foreign countries for coal and were forced to purchase it at extremely high prices. The necessity of procuring this necessary element for steam traction led to the consideration of finding a method of securing the economic independence of the country by providing a motive power which would be self sustaining and independent of foreign assistance during times of emergency. This situation led to the adoption of a plan of electrification of all the important lines in Switzerland by the General Direction of the Swiss Federal Railways. Before the war, the importation of coal for the Swiss Federal Railways amounted to an average of 700,000 tons. During the year 1923 the expenditures for coal amounted to $5,361,000, for a total distance of 18,019,-138 miles traveled by steam traction, showing an average price of 29 cents per mile for the cost of fuel in steam traction during the year 1923. A comparison of the cost of electric traction during the year 1923 with steam traction shows that in that period $1,457,730 were expended for electric power for a total distance traveled of 3,693,-247 miles by electric traction. This gives an average cost of electric traction of 38 cents per mile in comparison with 29 cents per mile for steam traction during the last calendar year.

The electric energy for the operation of the Chiasso-Basel line is furnished by two power plants at Ritom and Amsteg, aided by the Goeschenen plant at the Northern entrance to the Gotthard tunnel. Both plants can deliver throughout the year an average of 32,000 horsepower and it is expected with the completion of the full installation in the Ritom plant that 72,000 horsepower will be developed.

The express trains are drawn by electric locomotives weighing 112 tons and having a total length of 52 feet. These electric locomotives are capable on the maximum gradient of the Gotthard line, of a speed of 31 miles an hour with a 300-ton train and are constructed to furnish an average speed of 46.5 miles an hour, rising to 56 miles an hour in the valleys and on level ground. The last steam locomotives constructed for express trains in 1908 furnished a speed of 21.7 miles an hour with a train weighing 190 tons on the maximum gradient. These last steam locomotives purchased, cost $27,740 each, while the new electric locomotives were purchased at an average price of $152,000 each. The electric locomotives designed for freight service have a maximum speed of 40 miles per hour and weigh 128 tons. These can haul a train weighing 430 tons at an average speed of 21.7 miles an hour on the maximum gradient or a train weighing 300 tons at 31 miles an hour.

The Transcontinental Air Mail

Aeroplane mail service between New York and San Francisco, which was started on July 1, completed its first month of service without serious accident, but the postmaster general says that the financial success of the experiment is still to be demonstrated. The income was below the cost of operation and maintenance. The post office department intends to conduct an intensive campaign of traffic solicitation. So far as physical operation is concerned, the postmaster general has no hesitation in predicting success. In the 31 days of July, the mail planes flew 173,910 miles, and made an average time westbound of 39 hrs. 49 min.; average eastbound, 36 hrs. 21 min. The best railroad mail schedules are 86 hrs. westbound and 90 hrs. eastbound. Lights are being erected at the New York end and at the San Francisco end so as to facilitate the movement of planes approaching destination after dark.

A New Kind of Crossing Accident

The following message, which was received by Michigan Central officers from a representative on the line, indicates that the railways have a new problem to contend with: "C. Wark in charge of U. S. Plane 508, Detroit, Mich., about 8:30 a. m. today, crashed into our wires at first road crossing west of Tillsonburg, breaking all wires down except two and also breaking pole. Linemen are repairing wires."

Cars Ordered for Staten Island Electrification

Electrification of approximately 17 miles of double track passenger line of the Staten Island Rapid Transit Company and the Staten Island Railway Company is now under way, an order having recently been placed with the General Electric Company for eighty 2-motor equipments.

The motor equipments will be installed on subway type of steel coaches seating 71 passengers. Each coach is separately driven with two motors of 200 horsepower each, operating at 600 volts and equipped with G. E. type PC-10 control.

Trains from two to ten cars can be operated from one controller with a maximum speed of approximately fifty miles per hour. Current to the trains will be supplied through a top contact third rail.

The cars, which are to be manufactured by the Standard Steel Car Company, will be similar to those now operating in the subways of the Brooklyn-Manhattan Transit Corporation. Before going into operation the completed cars will be tested on the test tracks of the

General Electric Company at their Erie Works in Pennsylvania.

The Staten Island Rapid Transit Railway Company operates between St. George and South Beach and the Staten Island Railway between Clifton Junction and Tottenville. These lines are a part of the Baltimore and Ohio system.

Signal Section of A. R. A. to Give One Day to Train Control

At the fifteenth meeting of the Signal section of the American Railway Association which will be held at the New Ocean House, Swampscott, Mass., on September 23, 24 and 25, the second day, Wednesday, will be set aside for the discussion of the subject of automatic train control. The session will start at 8 a. m., Eastern time. All papers will be limited to 20 minutes. The program will be divided into three parts, the first covering tests conducted on the Pennsylvania, the Atchison, Topeka & Santa Fe, the Union Pacific, the New York Central, and the Southern Pacific. The second part will cover the relation of air brakes to train control and include an analysis of accident records. The third will cover installations now in service on the Chicago & Eastern Illinois, the Chesapeake & Ohio, and the Chicago, Rock Island & Pacific. Following the presentation of the subject matter above referred to, there will be five-minute discussions of the subject of train control by representatives of train control companies.

Personals

E. R. Chinberg, formerly electrical supervisor of the second district of the Chicago, Rock Island & Pacific Ry. has resigned and is now engaged in selling Lincoln welding equipment in California. Mr. Chinberg was in the employ of the Rock Island for about twelve years, the last five of which he held the position of electrical supervisor. D. E. Herndon, who was electrical foreman at Shawnee shops, has been appointed to succeed Mr. Chinberg and Oliver Lindell, one of Mr. Herndon's assistants, has been appointed foreman at Shawnee.

Obituary

George P. Finnigan, one of the pioneer inventors in the field of automatic train control, died at the City Hospital in Binghamton, N. Y., on August 29. Mr. Finnigan had been in ill health about three months and had been living at Greene, N. Y., near Binghamton, in which region he had had business interests for many years. His home was at Wilton-on-James, Va., near Richmond.

Mr. Finnigan may be classed as an amateur signal engineer, his chief interests for many years having been in horse breeding and other features of the live stock industry; but he was the first patentee of a train-stop device which included a permanent magnet on the roadway to function automatically to apply train brakes, and he had therefore become well known throughout the railway signaling world. He made experiments on the Delaware, Lackawanna & Western as far back as 1903; but he first became generally known when his apparatus was tried on the lines of the Interborough Rapid Transit Company in New York City about 1911. Later, he experimented for about a year on the New York division of the Pennsylvania.

Since the more general interest in the subject of automatic train control, following the government's sweeping order calling for the installation of train stops on prominent railroads, Mr. Finnigan's activities have been mainly on the Lackawanna, where he began systematic experiments early in 1922. At the largely attended hearing before the Interstate Commerce Commission in Washington in April of that year he made an extended statement, and announced that the Lackawanna road had joined him in comprehensive experiments intended to provide a suitable train control system for that road.

Up to a short time before his death he had been continuously engaged in this work, and an experimental installation has been in operation for several months. Mr. Finnigan's son, Earl Finnigan, who until recently has been engaged in other business, succeeds his father in the conduct of the Lackawanna experiments.

Trade Publications

Lightning Arrester Grounds is the title of a comprehensive publication being distributed by the General Electric Company. The pamphlet includes a total of 18 pages, illustrated with charts, photographs, diagrams and tables.

General Electric Company, Schenectady, N. Y., has just published an interesting illustrated bulletin showing some of its plants in various cities and also portraying the activities of many of its departments. The booklet contains 30 pages and gives a very clear insight into the busy workrooms of a large manufacturing plant.

Proposed Standards for Electric Arc Welding Apparatus is the title of a comprehensive pamphlet issued by the American Institute of Electrical Engineers. The aim of the bulletin has been to define the terms and conditions which characterize the rating and behavior of electric apparatus with a special reference to the conditions of acceptance tests.

The Electro Motive Company, Cleveland, Ohio, has recently published a bulletin describing gas-electric motor cars, models SE and DE which it manufactures. Elevations and plan views of the cars are given together with many dimensions. Full information concerning the structural details is presented along with the car measurements. A table of speeds in miles per hour under average conditions is given as well as curves showing fuel consumption, tractive effort and train resistance. On page 11 an interesting tabulation is given showing the operating cost per car mile in average service.

Westinghouse Railroad Data. This publication is 5¾ in. x 6¾ in., is in loose-leaf form and the pages are assembled into a flexible cover. The subjects covered include outline drawings and data on specific electric locomotives, a tabulation of data on representative modern steam locomotives, a complete tabulation of data on electric locomotives of North and South America, information and curves on train resistance, information and data on arc welding, wheel lathe equipment and direct current reversing motor planer equipment, turntables and transfer tables, data on general motor application, power factor correction, and general data on weights, etc.

Railway Electrical Engineer

Volume 15 OCTOBER, 1924 No. 10

The Committee Reports

This issue of the *Railway Electrical Engineer* contains in their entirety the reports of the various committees of the Association of Railway Electrical Engineers. These will be presented at the annual convention of the association in Chicago on October 21 to 24. Never before have there been such extensive reports or such a large number of them. They portray faithfully just what the electrical men on the steam railroads are doing, and one needs but glance at the extent of some of them to appreciate the tremendous strides that have taken place in the application of electricity to the requirements of steam railroad operation. The work of the railway electrical engineer has grown with each succeeding year until there is scarcely a department which has not in some measure had occasion to make use of his services.

The number of reports is too large to give individual mention of each in this limited space, and it is sufficient to say that everyone of them touches upon some important development in the general scheme of applying electricity to railroad requirements. These reports bring to you the latest developments effected by the leading men in the electrical departments, and they afford an unusual opportunity for the readers of the *Railway Electrical Engineer* to keep abreast of the times.

The Subject of Illumination

The report of the Committee on Illumination is most impressive because of its unusual length. There is, perhaps no other use of electric energy which is more important than that which provides adequate lighting facilities for the performance of innumerable operations which must be carried on twenty-four hours of the day. The lighting values of a few years ago have been greatly improved. Better lamps have been provided, and while actually less power is used per unit, the lighting intensities are very much higher than they have been in the past. Just how far progress in this direction will continue is impossible to prophesy, although it is not unreasonable to conceive that by the proper use of correctly designed lighting units artificial light will eventually reach a stage where it will equal, if not surpass, daylight as a means for improving working conditions.

Before this can be accomplished, however, correct use of lamps and reflectors must be understood and the methods of lighting and types of equipment must be minimized. The report represents the first part of a lighting manual, and when this manual is completed the information contained in it will be such that proper lighting methods for all kinds of railroad conditions will be covered. Average railroad lighting in quality is not on a par with industrial lighting. The manual will, however, undoubtedly prove an effective means for wiping out this disparity.

Train Lighting Practice

The report of the Committee on Train Lighting Equipment and Practice which is published elsewhere in this issue shows that the problems now demanding the attention of the car lighting engineers have to do with axle pulleys, suburban coach lighting, batteries and lamps. With regard to generators, regulators and lighting fixtures the report states that manufacturers and users have been able to co-operate in a highly satisfactory manner, with the result that the car lighting of today renders a service subject to less criticism than ever before. This is a result of the high degree of standardization of this equipment that has been attained. When standardization is possible it is usually accompanied by dependability and high efficiency.

The kinds of apparatus receiving the attention of the committee also represent a high state of development, but it is apparently felt by the users that much is to be gained by certain changes and adaptations. There are great possibilities in the design of axle pulleys. If a pulley can be devised which will do away with the loss of belts, large savings will be effected. Direct drives and improved types of pulleys are being tried out in an effort to accomplish this result. The lighting of suburban trains by the head-end system is a relatively new practice, and it is natural that few standards have been established, particularly as local conditions vary widely. It is a subject which will probably receive a considerable amount of attention during the next few years. A greater space underneath the plate groups in batteries has been suggested to prolong the time between cleaning periods to conform with already lengthened shopping periods for cars. This is a step in the right direction, and it is possible that much more can be accomplished than is being attempted. Some lead batteries, given adequate sediment space and proper charging, have been kept in car lighting service for periods of four years without cleaning, and it is not unthinkable that this should become common performance. The improved types of hard rubber jaws are apparently finding universal favor. Car lighting lamps have been highly standardized, and unnecessary sizes of lamps and types of bulbs have been eliminated.

Summing up the present situation with regard to apparatus it may be said generally that such improvements

as are being made are matters of perfection of design. The equipment has reached a high state of standardization and minor changes and improvements are made from time to time to comply with changing requirements and improvements in manufacture. This is not true of the various methods used by the railroads for maintaining apparatus. This subject has been given very little publicity, and due to the widely separated points at which the work is done it is difficult for any one to acquaint himself with the many different practices. If you have developed methods or equipment in your shop that others would like to know about, or if you know of someone else who has, you will do a favor to everyone concerned if you will tell the *Railway Electrical Engineer* where and by whom this work is being done. Descriptions of such methods and devices should do much toward simplifying the work of maintaining car lighting equipment.

The Gas Electric Car

Among other reports which touch upon the urgent problems of the day is that of the Committee on Self-Propelled Cars. The roads are being compelled to make use of these units of transportation purely from the standpoint of economy. Practically any of the self-propelled cars now manufactured can be operated at a lower cost than steam equipment, although there is quite a wide variation in the efficiencies of the several types. Opinions seem to differ as to the relative merits of the straight gasoline car and the gasoline-electric or gasoline cars with oil transmission. Unquestionably the straight gas car is cheaper to purchase and cheaper to operate than the gasoline-electric because of the higher efficiency of energy transformation and the lower weight of the straight gas car. Yet the gasoline-electric unit has smoother acceleration and has the advantage of double end operation which the straight gas does not possess. That there will be greatly increased use of self-propelled cars in the near future seems to be almost a certainty, and it has been stated by one engineer deeply interested in this subject that as much as 30 per cent of existing passenger traffic could be economically carried in this kind of equipment. If this estimate is even approximately true it would mean that much heavy equipment would be justified and in all probability gasoline-electric cars would be very largely adopted in spite of the fact that they do not possess the high fuel efficiency and low first cost that the straight gas cars enjoy. With this prospect in view the electrical engineer may be reasonably assured that he will have to give considerable thought to the gasoline-electric cars.

"Last Call" for the Convention

The importance of your attendance at the 15th anniversary convention of the Association of Railway Electrical Engineers is something which should not be minimized. The amount of good that you can carry away from these meetings is quite impossible to estimate. The convention furnishes the one big opportunity of the year for all electrical men to get together and freely discuss the numerous and frequently vexatious problems which are giving them concern. It is safe to say that there is not a single railway electrical engineer who has not some problem which is giving him more than an ordinary amount of trouble and the opportunity to meet with other men who are dealing with similar conditions is a thing which none can afford to pass lightly by.

Those men who must necessarily come long distances to attend the convention are, of course, under the greatest handicap, and in some instances there will undoubtedly be powerful influences which will tempt them to forego the opportunity to go to Chicago. Emergencies arise occasionally which make it absolutely impossible for a man to be away from his post of duty at a certain time, but fortunately, for the most part, these cases are not frequent, and the electrical man will do well to weigh the necessity of staying away with the importance of going. Such a wealth of information has never been presented before at any convention of the Association of Railway Electrical Engineers, and the large number of reports is certain to be an accurate measure of the benefit which those in attendance will derive from the meetings.

The scope and volume of the reports may readily be appreciated from the copy of the *Railway Electrical Engineer* which you now possess, but that intangible value which comes from discussion and association with those interested in the same problems, you can only secure by being on hand when the gavel falls. Don't make the mistake of staying away if it is at all within the bounds of possibility for you to come. You will broaden your own vision and strengthen your ideas and last, but not least, you will carry away with you new ideas which are certain to react to the benefit of the road which employs you.

New Books

The British Engineers' Association Directory of Members and Their Manufactures. Published by the British Engineers' Association, London, 318 pages, 4¼ in. by 6¾ in. bound in semi-flexible covers, imitation leather.

The object of the Directory is to provide information of real use to all interested in British engineering products. It contains the names, addresses, telegraphic addresses, codes, and full details concerning British Manufacturing engineers, and includes practically every known manufacturer. This is the sixth edition and with the present issue of 20,000, a total free distribution of seventy thousand copies is reached.

Electrical Railway Hand Book. Second Edition. By Albert S. Richey, E. E., 785 pages, illustrations and diagrams, 4¼ in. by 7 in. Bound in semi-flexible covers, imitation leather. Published by McGraw Hill Book Company, New York City, Price $4.00.

The aim of this handbook has been to get together in compact form a large amount of information which the electrical railway engineer frequently requires, but seldom finds, only after continuous search through many handbooks and technical journals. Detailed material relating to power plants has not been included, as this field is well covered by many existing text books. In the section on buildings the field of the architect has been entered practically only so far as electric railway building problems may differ from others. In short, it has been the aim to present data on the subjects which come up in every day electric railway practice for constant use by operating, constructing and designing engineers.

The eleven sections of the book deal respectively with roadbed and track, carhouse and shops, train movement, railway motors, controlling apparatus, current collecting devices, trucks, braking, cars, transmission and distribution and signals and communication.

Chicago's New $65,000,000 *Union Station Nears Completion.*

Association of Railway Electrical Engineers Fifteenth Annual Convention

October 21st to 24th, Chicago

CONVENTION PROGRAM

Meetings in the East Room, Mezzanine Floor, Hotel La Salle,
Exhibits Will Occupy Entire 19th Floor

TUESDAY, OCTOBER 21st

Session 10:00 A. M. to 12:00 Noon

Address of President.
Report of Secretary-Treasurer.
Report of Auditing Committee.
Unfinished Business.
New Business.
Election of Officers.
Sponsor Committee on Insulated Wires and Cables (of American Engineering Standard Committee).

WEDNESDAY, OCTOBER 22nd

Session 9:00 A. M. to 12:00 Noon

Committee on Economics of Electrical Appliances (page 353).
Committee on Power Trucks and Tractors (page 340).
Committee on Electric Welding (page 352).
Committee on Electric Storekeeping (page 346).

THURSDAY, OCTOBER 23rd

Session 9:00 A. M. to 12:00 Noon

Committee on Safe Installation and Maintenance of Electrical Equipment (page 336).
Committee on Illumination (page 312).
Committee on Self-Propelled Cars (page 345).
Committee on Starters and Controllers (page 350).
Paper by R. E. Wade, of General Electric Company, on "Trolley Line Construction, Heavy Electric Traction" (page 358).

FRIDAY, OCTOBER 24th

Session 9:00 A. M. to 12:00 Noon

Committee on Automatic Train Control (page 341).
Committee on Locomotive Lighting (page 335).
Committee on Train Lighting Equipment and Practice (page 348).
Committee on Aplication of Radio to Moving Trains (page 338).
Committee on Power Plants (page 344).

Registration

Please register and secure badges at Secretary's desk. Located in hall on the nineteenth floor.

Theatre and dinner tickets should be reserved at the time of registering.

Entertainment

Exhibits are located in the Grand Ball and Red Rooms on the nineteenth floor and will be open from Monday evening until Friday noon.

Wednesday evening, October 22—Carnival Dance, Louis XVI Room on the main floor, 9:00 P. M. Admission by badges.

Thursday afternoon, October 23—"Ladies' Card Party," five hundred and bridge, East Room, mezzanine floor, 2:30 P. M. Admission by ticket, Secretary's desk.

Thursday evening, October 23—Theatre Party for both ladies and gentlemen: "No, No, Nanette," Harris Theatre, 170 N. Dearborn street. Secure tickets at Secretary's desk from Wednesday noon up to Thursday noon. Tickets should be reserved at time of registering.

Friday evening, October 24—Fifteenth Anniversary Dinner-Dance and Entertainment, Grand Ball Room, nineteenth floor, 7 P. M.

Secure tickets at Secretary's desk beginning Wednesday afternoon.

Report of Committee on Illumination

Present Report Marks Beginning of Work on Manual Suggested By Committee at June Convention

Committee:—
L. S. Billau, chairman, assistant electrical engineer, Baltimore & Ohio R. R.; G. H. Caley, electrical and signal engineer, New York, Ontario & Western Ry. Co.; G. T. Johnson, assistant engineer, New York, New Haven & Hartford R. R. Co.; J. L. Minick, assistant engineer, Pennsylvania Railroad System.

TO THE MEMBERS:

Your Committee on Illumination submits the following report on subjects that have been assigned to it for consideration:

Incandescent Lamps for Train Lighting Service

There have been no material changes in train lighting lamps during the past year, but there have been some slight changes in the lumen values for nearly all of the lamps covered in this schedule, as will be noted by comparing tables 1 and 2 with corresponding tables published in the report of the committee last year. The efficiency of the 50, 75 and 100 watt "C" lamps in the 30 to 34 volt range has been further improved. The use of the type C lamp is increasing, but not as rapidly as the advantages to be gained with this type of lamp would justify. In the 50 watt size, however, the use of the type B, or vacuum lamp, has nearly disappeared.

The subject of the standardization of trainlighting lamps is one worthy of careful consideration by the railroads during the next few years. If the railroads are to enjoy the benefits of reduced cost as well as better service in obtaining trainlighting lamps, it is essential that this line of lamps be simplified to a greater degree than it has been in the past. At the present time the demand for trainlighting lamps covers eleven different voltages, in the 30 to 34 and 60 to 65 volt range, seven different wattages from 10 to 100 watt, three different styles of bulbs (straight side, round and pear shaped) and three different finishes of bulbs (clear, bowl frosted and all frosted). It is highly desirable that this line be reduced to the minimum number of varieties consistent with meeting the demands of the various systems of trainlighting. Your committee would again call attention to the sizes and types of lamps that the association has adopted as recommended practice to meet the general requirements of trainlighting service. It is now proposed to add the 15 watt type C lamp and change the voltage from a range of 30 to 34 to one voltage, viz., 32. The complete list with recommended changes is given in table 3. Both the type B and type C 15 watt lamps are included as there is a large demand for the former to meet the requirements of incidental lighting such as vestibule, passageways, etc., where a highly efficient lamp is not essential. It is expected that this lamp will be eventually eliminated as the efficiency is improved and the cost reduced of the 15 watt type C lamp.

TABLE 1

LAMPS FOR WHICH THERE IS A LARGE OR INCREASING DEMAND

Size in Watts	Type and Size of Bulb	Vacuum (B) or Gas Filled (C)	Rated Initial Lumens	Approximate Mean Lumens Throughout Life	Approximate Present Annual Demand Number of Lamps	Per Cent of Total
			30-34 VOLT RANGE			
15	S-17	B	153*	133*	360,000	15.2
15	G-18½	B	141*	123*	560,000	23.6
15	PS-16	C	151	142	73,000x	3.1
25	S-17	B	273*	219*	255,000	10.7
25	G-18½	B	243*	207*	220,000	9.3
25	PS-16	C	310	285	165,000x	7.0
50	PS-20	C	740*	700*	315,000x	13.2
75	PS-22	C	1215*	1150*	30,000	1.3
100	PS-25	C	1700*	1610*	15,000	0.6

* Indicates a change.
x Includes frosted.

TABLE 2

LAMPS FOR WHICH THERE IS A LIMITED OR DECREASIND DEMAND

Size in Watts	Type and Size of Bulb	Vacuum (B) or Gas Filled (C)	Rated Initial Lumens	Approximate Mean Lumens Throughout Life	Approximate Present Annual Demand Number of Lamps	Per Cent of Total
			30-34 VOLT RANGE			
15	PS-16 Frosted	C	139*	118*	.....	....
25	PS-16 Frosted	C	276*	246*	.....	....
50	PS-20 Bowl Frosted	C	700*	660*	.....	....
			60-65 VOLT RANGE			
15	S-17	B	144	125	60,000	2.5
15	G-18½	B	129*	112*	155,000	6.5
25	S-17	B	255*	204*	50,000	2.1
25	G-18½	B	235	200	40,000	1.7
50	PS-20	C	565*	515*	55,000	2.3
75	PS-22	C	1005	905	15,000	0.6
100	PS-25	C	1430	1260	8,000	0.3
				Total	2,376,000	100.0

* Indicates a change.

TABLE 3

Size in Watts	Voltage	Bulb	Vacuum (B) or Gas Filled (C)
15	32	S-17	B
15	32	PS-16	C
25	32	PS-16	C
50	32	PS-20	C
75	32	PS-22	C
100	32	PS-25	C

For the 60 to 65 volt range, the use of one voltage, 64, is recommended.

As regards bulb finishes for the type C trainlighting lamps the all frosted bulb seems the most desirable from the illumination point of view for the 15 and 25 watt sizes and the bowl frosted lamp for the 50 watt size (where used in an open reflector), but frosted lamps have not been very satisfactory in trainlighting service due to the problem of cleaning. The lamp manufacturers are working on this problem and the indications are that an improved type of frosted lamp may eventually be developed which will be more satisfactory for this class of service.

Incandescent Lamps for Locomotive Service

The new S-14 bulb cab lamp is being used to a larger extent and it is reported that one railroad has adopted it as their standard. Your committee feels there is not yet available sufficient data on the performance of this lamp in actual service to propose its general adoption with the gradual elimination of the S-17 bulb lamp. The lamp manufacturers are making further developments in the construction of this lamp and it is therefore recommended that the railroads continue to try out the lamp on a larger scale during the coming year.

Further laboratory tests by the lamp manufacturers and service tests by some of the railroads have been made with 250 watt headlight lamps in G-25 and P-25 bulbs, but these are not yet sufficiently extensive or complete to permit drawing conclusions as to their relative merits in comparison with the performance of the lamp in the G-30 bulb.

Your committee strongly urges that the railroads adopt but one voltage rating for each of the classes of lamps used in locomotive service. These are 32 volts for headlight lamps and 33 volts for cab lamps.

Digest of Industrial Lighting Codes That Have Been Issued by Various States

In 1922 the report of the Committee on Illumination included a digest of lighting codes, laws, or other regulations pertaining to industrial lighting that have been put into effect by various States. With a view to keeping this information up to date this committee will include in its annual reports revisions and additions to these codes that have been put into effect during the year. The following additions and revisions have been made since those reported in the 1923 report:

Since the last report on State Lighting codes was rendered the states of Washington and Oklahoma have adopted lighting legislation.

The following extracts are taken from the Safety Standards of the Department of Labor and Industries, State of Washington, effective January 1, 1924. Standards No. 14 to No. 20 inclusive on pages 6, 7, 8 and 9 cover lighting.

Standard No. 14 is general and relates to the Application of lighting and illumination.

Standard No. 15 covers Definitions.

Standard No. 16 covers Intensity required.

Standard No. 17 covers Natural lighting.

Standard No. 18 covers Character of lighting to be supplied.

Standard No. 19 covers Shading of lamps.

Standard No. 20 covers Diffusion and distribution of artificial and natural light.

These Standards are based in part upon the I. E. S. (American Standard) Code and in part on the Wisconsin and other state industrial lighting codes.

The Standard on Intensity Required contains a departure from all other codes in that it has three parallel columns specifying (1) Minimum permissible foot-candles on the space or at the work; (2) Recommended intensities of good practice; (3) Recommended productive intensities. This Standard is quoted in full as follows:

	Minimum Permissible Foot-Candles on the Space or at the Work (1)	Recommended Intensities of Good Practice (2)	Recommended Productive Intensities (3)
(a) Roadways, yard thoroughfares	0.2	.5 to 1	....
(b) Storage spaces, aisles and passageways in workrooms, excepting exits and passages leading thereto	.25	.7 to 2	....
(c) Where discrimination of detail is not essential. Spaces such as hallways, stairways, exits and passages leading thereto; toilet rooms, elevator cars and landings	.50	.1 to 2	5 to 8
(d) Work such as handling material of a coarse nature; performing operations not requiring close visual application; grinding clay products, rough sorting, coal and ash handling, lumber handling	.50	1.5 to 3	5 and up
(e) Where slight discrimination of detail is essential; spaces such as foundry charging floors, stairways, passageways and other parts of industrial plants, lumber mills, etc., where there are exposed moving machines, hot pipes or live electrical parts; work such as rough machining, rough assembling, rough bench work, rough forging, grain milling	1.0	2.5 to 5	8 and up
(f) Where moderate discrimination of detail is essential; work such as machining, assembly work, bench work, fine core making in foundries, cutting shingles, preserving and packing fruit, sawing, planing, sanding and strapping lumber.	2.0	.4 to 8	10 and up
(g) Where close discrimination of detail is essential; work such as fine lathe work, pattern making, tool making, weaving light colored silk or woolen textiles	3.0	.6 to 8	15 and up
(h) Where discrimination of minute detail is essential; work such as watchmaking, engraving, sewing dark colored material.	5.0	.7 to 10	20 and up

Note.—The intensities listed in column (1) specify the lowest illumination with which workmen can work with safety.

The intensities listed in column (2) are those employed in well-lighted modern factories, where the aim has been to reduce eyestrain to a minimum.

The intensities listed in column (3) are those employed in factories where the management aims at securing the maximum of production and minimum of spoilage.

The code of Oklahoma contains the following general provisions:

Rule 1 describes the work places which shall be lighted, and the locations where the specified intensities are to be measured, and then gives a general list of work classifications with specified intensities. Supplementing this general list is a detailed list of industrial operations with the minimum intensity permitted.

Rule 2 concerns glare and the shading of lamps.

Rule 3 concerns distribution of light.

Rule 4 concerns emergency lighting.

Explanations of the various rules are then given, followed by a provision for penalties for failure to comply with the code. The penalties provided are as follows:

A fine of not less than $10 or more than $100 for each offense.

The State of Pennsylvania recently revised its code of lighting, considerably amplifying the list of industrial operations with their specified minimum intensities. A penalty is also specified for failure to comply with the Pennsylvania code, this penalty being as follows:

Every person or persons who violate any of the provisions of these rules of the Industrial Board, or who interfere with the Secretary or his duly authorized representative in the enforcement of these rules, shall be deemed guilty of a misdemeanor, and may, upon conviction thereof, be punished by fine or imprisonment, or both.

Flood Lighting System of Illumination for Railroad Yards

Your committee was directed to continue its study of the subject of the illumination of railroad yards by means of the flood lighting system. As there has been comparatively little development work along these lines during the past year that has reached the state where installations are in actual service, it has not been possible to give this subject as much consideration as desired. There are indications that this system is rapidly becoming standard for modern illumination practice for classification yard service. From an incomplete survey there have been reported 35 railroads having 90 yards equipped, using approximately 2,100 flood lighting units.

From data compiled by one railroad for a period of several months before and after one of their classification yards had been equipped with a modern flood lighting installation (there having previously been no artificial illumination in this yard), the following results have been secured:

1. Per cent increase in number of cars handled night-time after installing lighting system, 15.5.
2. Per cent decrease in average cost of damage per car handled at night-time, 21.
3. For period under observation there were 12 personal injuries occurring at night-time, while for corresponding period, after installation of the system, there were none that could be attributed to lack of illumination.
4. Lighting system claimed to be of valuable assistance to the police department in carrying on policing work, etc.

Manual of Lighting Practice for Railroads

The requirements of the various state lighting codes as applying to artificial illumination represent minimum intensities, etc., necessary for safety, although most of the codes now include specific recommendations covering best modern illumination practice. In many of the industries intensive studies of the illumination problem have been made by experienced illuminating engineers and the results published and distributed, with a view to aiding the industries in modernizing as well as standardizing their lighting practice.

The railroads as a whole have not kept pace with the development that has taken place in other fields. As an aid to the members of the association in modernizing antiquated lighting installations, or laying out new ones, it is felt that similar data covering the best practice as applied to the illumination problem to be met in the railroad field would be of considerable value. Your committee has, therefore, been directed to prepare a manual of Lighting Practice for Railroads, in which it is proposed to cover the following subjects:

1. Fundamentals of illumination and general design data.
2. General shops and round houses.
3. Offices, drafting rooms, etc.
4. Passenger stations.
5. Freight stations.
6. Storehouses, warehouses and covered piers.
7. Yards, scale houses.
8. Car lighting.
9. Special and miscellaneous.

For this year's work it has been possible to prepare the illuminating engineering data for subjects 1 and 2 only, and the latter not completely. These are presented in Appendix A. Obviously there is a wide range of subject matter that can be covered under these subjects. It is the desire of the committee to include only such information as will be of practical value to avoid making the manual too voluminous yet be complete enough to include such of the fundamentals of illuminating engineering practice as to be of benefit to those who have not had opportunity to go into the subject to any great extent. Before proceeding further with this work, the committee desires to obtain constructive suggestions from as many of the members as possible. It has already been suggested that, in addition to covering the engineering data, when the manual is published there be included data and recommendations covering the best wiring practice as determined from the experiences of various railroads.

Recommendations

Your committee recommends that the association take definite action on the recommended sizes, types and voltage of train lighting and headlight lamps that have been proposed as recommended practice, and that the work in connection with the preparation of the lighting manual be continued.

Respectfully submitted,
COMMITTEE ON ILLUMINATION.

APPENDIX A—MANUAL OF LIGHTING PRACTICE FOR RAILROADS

SECTION 1—Fundamentals of Illumination and General Design Data

MAZDA LAMPS

100. Operating Principles of Mazda B Lamps

Until about 1913, the filaments of all commercial electric incandescent lamps were operated in bulbs from which practically all air and gases had been removed. The evacuation of the bulb accomplishes two purposes: First, it prevents the filament being consumed by the oxygen of the air; second, it prevents the loss of heat from the filament by conviction. As the temperature of the filament of a lamp is raised, the light given out increases much more rapidly than the energy consumed; but, on the other hand, the rate of evaporation of the filament is increased. It is, therefore, desirable from the standpoint of efficient transformation of electric energy into light to operate the filament at the highest temperature that it can withstand without causing it to evaporate at an excessively rapid rate. The rate of evaporation of a given filament at a certain temperature, and consequently the life of the lamp, depends upon the ability of the filament to withstand evaporation. There is a great difference in this respect in the various materials which may be used as filament, and this is one reason why it is possible for the metallic-filament lamps to produce so much more light for a given consumption of energy than the older carbon-filament lamps, and give at the same time a more satisfactory life performance. It would be possible to operate the ordinary carbon lamps at an efficiency as high as that of the metallic-filament lamps, but the life would be so short as to preclude their use commercially at such an efficiency.

101. Operating Principles of Mazda C Lamps

It is seen, then, that if the rate of evaporation can be reduced, the filaments can be operated at a high temperature and, other things being equal, at a higher efficiency. Inert gases introduced into the bulb increase the pressure bearing upon the filament, and the practicable operating temperature can thereby be increased. However, with lamps where the filaments of ordinary size are mounted in the regular way, the loss due to heat being conducted away by the gas is great enough to more than offset the advantages obtained by operating the filament at a higher temperature. The development of the helically coiled tungsten filament permitted mounting in a small space, near the center of the bulb, and the percentage loss through the gas was greatly reduced, with the result that these Mazda C lamps became at once commercially practical in the higher wattages.

As the heat carried away by the gas from a thin filament of low wattage is proportionately greater than from a thick filament of high wattage, there is, therefore, a wattage below which Mazda B lamps become more efficient than Mazda C lamps of the same volt-

age and rated life. It is expected, however, that future developments will produce quite as satisfactory Mazda C lamps in the lower wattages.

102. Typical Lamp Performance

The amount of light produced by incandescent lamps decreases as the lamps become old in service. It is important, therefore, in planning illumination to know how the average light output compares with the initial value. Moreover, to make a careful analysis of the cost of lighting, it is necessary to know the *average* efficiency with which light is produced by a lamp throughout its entire period of service. The rated life of a lamp must be considered as the average of a group of lamps of that size and type, and not as the life that can be expected of individual lamps.

The amount of light given by a lamp is measured in terms of lumens (indicating the total volume of light), or in spherical candlepower (indicating the average intensity in all directions). The efficiency with which a lamp converts electrical energy into light is best indicated by the amount of light produced per watt consumed. The specific output measured by the lumens per watt has been adopted as a direct means of expressing lamp efficiency. A lamp operating at 20 lumens per watt is twice as efficient as one operating at 10 lumens per watt.

The performance which a group of lamps may be expected to give in service varies with the character of the service and the method of installation. A group of lamps which under the tests prescribed in the standard specifications may be expected to have an average life of 1,000 hours, could not be expected to give a similar performance under unsatisfactory service conditions.

It is expected that where the regulation of the circuit voltage or current is good, and where the average value of the voltage or current while the lamps are burning is the same as that of the lamp label, a performance of approximately that given in the following table for the various lamps may be expected.

The above statement includes the necessity of proper installation, as Mazda lamps cannot be expected to give their full rated life unless the service is as good as that given above and the lamps are protected from excessive vibration or intermittent shocks. Lamps when fitted with reflectors, or enclosed in a housing of any kind, can only be expected to give full average service life when these reflectors, enclosing mediums or housings, are properly designed so as not to overheat any part of the lamp. In general, Mazda C lamps do not decline in light output as much as Mazda B lamps of the same voltage. Both the average light output and the average efficiency throughout life can be obtained from tables issued by the lamp manufacturers.

To illustrate this further, the following figures may be given as representing the number of lamps out of an original lot of 100-60 watt Mazda B lamps which might be expected to be burning at the end of various periods of service, as indicated above. It should be remembered in considering this table that the data are typical of 60-watt Mazda B lamps of the standard voltage range. Other sizes and types of lamps have different characteristics; small lamps, for example, having a larger number of early burnouts than some of the larger sizes.

The table, therefore, will serve to illustrate only the more usual standard types of multiple lamps and is not necessarily exactly representative of lamps for stereopticon service, locomotive headlight service, street railway service, flood lighting service, round bulb lamps, tubular bulb lamps or the Mazda C lamps of any of the various sizes. However, the same principle applies in a general way to all lamps.

Hours Burned:										
0	200	400	600	800	1,000	1,200	1,400	1,600	1,800	2,000
Number of Lamps Remaining:										
100	99	97	91	75	50	25	9	3	1	0

Although not given as a basis of guarantee, the rated average total life of most of the usual sizes of large Mazda lamps listed on the regular schedules is 1,000 hours. Following are some of the exceptions:

Mazda B lamps for ornamental lighting service; round bulb lamps, 750 hours; 25 watt T-10 bulb lamps, 600 hours; 40 watt T-8 bulb lamps, 600 hours.

Mazda B lamps for sign lighting service, 1,500 hours.

Mazda B lamps for electric street railway service, 1,500 hours.

Mazda C lamps for street lighting service, 1,350 hours.

Mazda C lamps for locomotive headlight service, 30-34 volts, 500 hours.

Mazda daylight lamps, 700 hours.

Mazda C lamps for stereopticon and motion picture projection service, 100 hours.

Mazda C lamps for flood lighting service, 800 hours.

103. The Effect of Lamp Voltage Upon Lighting Service

The importance of operating lamps at their rated voltage is illustrated by the curve in Fig. 1, which shows how the lumen output of a lamp is affected by operating it at various voltages. The efficiency of the lamp when operating at rated voltage is such that for average conditions of cost of electric energy and cost of lamp renewals the total unit cost of light produced will be a minimum.

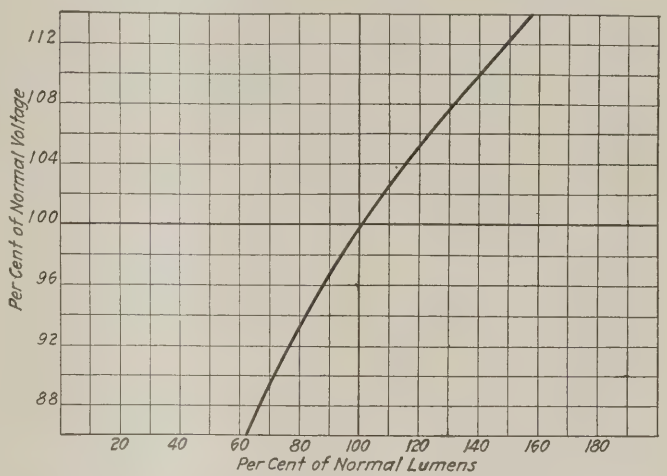


Fig. 1—Variation in Lumens with Voltage for Mazda Lamps

For classes of service where the energy rate is low, as frequently exists in the railroad field, the fixed investment and cleaning cost assume importance and justify a higher operating efficiency than a consideration of the energy and renewal expense would indicate. energy rates decrease, ordinarily makes it economical to use lamps of a labeled voltage no higher than the circuit voltage, even when The increase in the relative importance of these fixed charges as the energy rate is low.

UNITS OF MEASUREMENT

104. Candlepower

Candlepower is a unit of intensity with which direction is associated. It has been arbitrarily defined as the intensity of light in a direction at right angles to the axis of a candle of certain specifications. The candlepower of a light source is the measure of strength of the source to produce illumination in a given direction. Candlepower is analogous to a measurement of the depth of a pool of water at a certain point—a measurement which is useful for certain purposes, but in itself gives no indication of the quantity of water in the pool.

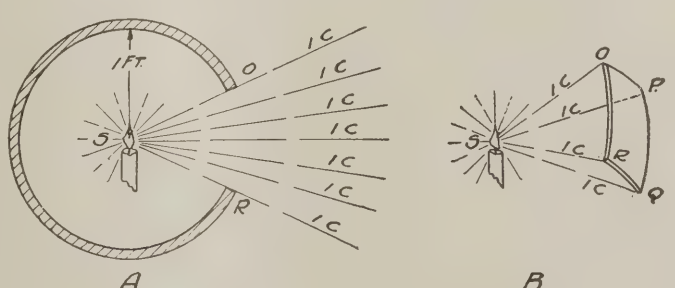


Fig. 2—(A) Opening OR Has Area of One Square Foot and Emits One Lumen; (B) One Lumen Falls on Surface OPQR; (S) One Candle Power

Closely related to candlepower is the mean spherical candlepower. The mean spherical candlepower of a light source is simply the average of all the candlepowers in all directions about that source.

105. Lumen

Since candlepower does not express quantity of light, it was necessary to develop a unit whereby the total flux of light emitted by a source may be obtained. This unit expressing quantity of light is the lumen and is defined as the quantity of light emitted in a unit solid angle. It may be expressed in another way by stating that one lumen equals the quantity of light incident upon a surface one square foot in area illuminated uniformly to an intensity of one foot-candle. In Fig. 2 is shown a graphical illustration.

Here A represents a light source giving one candlepower in all directions and is surrounded by a non-reflecting sphere one foot in radius through which is cut an opening, $OPQR$, which has an area of one square foot and subtends a unit solid angle. Through this opening the light source, S, emits one lumen. As the entire surface of the sphere equals 12.57 square feet, the total flux emitted by S equals 12.57 lumens. In other words,

Total lumens $=$ 12.57 $\times$ mean spherical candlepower.

Referring again to the comparison to a pool of water, lumens would be analogous to the measurement of the total quantity of water in the pool. Such a measurement could be determined by dividing the surface into a large number of equal squares and measuring the depth at the center of each; the average depth thus found would give a definite idea of the quantity of water in the pool since the area is known. This average depth corresponds to the average intensity of light in all directions, or the mean spherical candlepower, and the area of the pool corresponds to the area of imaginary sphere about the light source, the product of which gives the total lumens representing the total quantity of light emitted.

106. Foot-Candle

Foot-candle is the unit of illumination. The foot-candle represents the intensity of illumination equal to that produced at a point on a plane which is one foot distant from a source of one candlepower and which is perpendicular to the light rays at that point.

The intensity of illumination varies inversely as the square of the distance from the light source and may be expressed mathematically by the equation:

$$\text{Intensity (foot-candles)} = \frac{\text{candlepower}}{(\text{distance})^2} \times$$

cosine of angle of incidence, where the angle of incidence is the angle between the perpendicular to the plane at the point under consideration and the light ray. This law is illustrated graphically in Fig. 3.

Thus in Fig. 3 a surface B, twice the distance from S that A is, will be illuminated by the same number of light rays, but as the area is four times as great, the illumination will be only one-

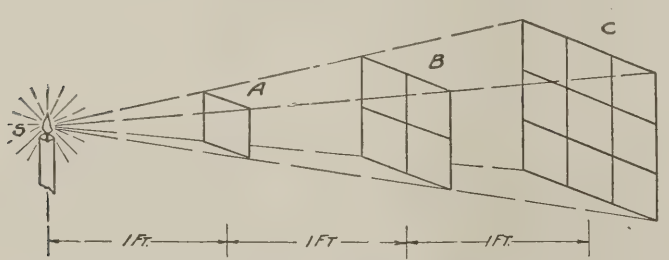


Fig. 3—The Illumination on the Surface Varies Inversely as the Square of the Distance from the Source to the Surface

fourth that on A. Likewise C, which is three times the distance and nine times the area of A, will have only one-ninth the illumination.

107. Luminosity

Luminosity expresses the brightness of surfaces from which light arises as the result of either light emission or light diffusion. Luminosity is measured by the light flux emitted per unit area. The luminosity of primary light sources is referred to as intrinsic brilliancy, a term which generally denotes the luminous intensity per unit area of the source. A common way of expressing luminosity of brightness is in candles per square inch.

108. Foot-Candle Measurements

An instrument called the foot-candle meter has recently been designed to measure foot-candle intensities quickly and with a fair degree of accuracy. It is very simple in operation, so light that it can be easily carried about, and so small that readings can be taken in very restricted spaces. The instrument is shown in Fig. 4. In operation, it is placed upon or adjacent to the surface on which a measurement of the foot-candle intensity is desired. A lamp within the box illuminates the under side of the screen to a much higher intensity at one end than at the other. The illumination which it is desired to measure is, of course, practically uniform over the entire scale.

Closely spaced translucent dots line the scale from end to end. If the illumination on the scale from the outside falls within the measuring limits of the meter (1.2-50 foot-candles), the spots will appear brighter at one end of the scale than at the other, and at the point where the spots are neither brighter nor darker than the white paper scale, the illuminations from within and from without are equal. The scale is accurately calibrated, with the lamp within

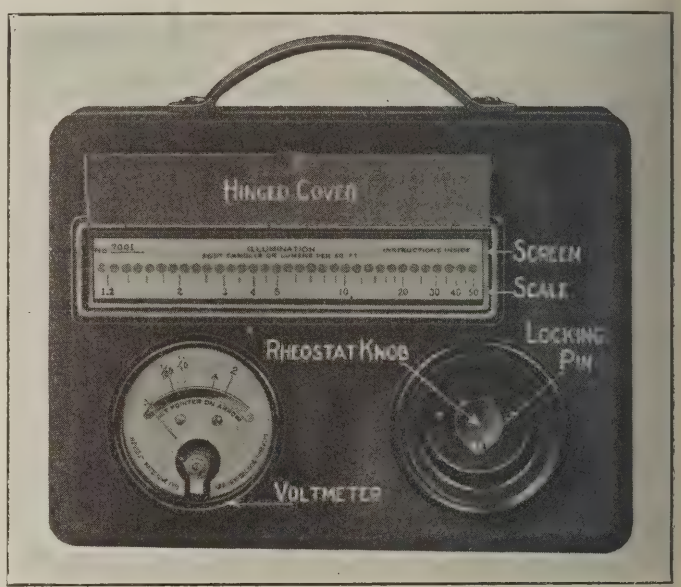


Fig. 4—Foot Candle Meter

the box burning at a certain definite voltage. A voltmeter and rheostat enable the operator to adjust the lamp voltage to four different values, which permit the instrument to be used for intensities ranging from a minimum of .012 to 100 foot-candles. The energy is supplied from small dry cells.

This instrument is proving very serviceable for "checking up" installations to insure, for example, that the illumination is ample when the lighting equipment is in first-class shape and to see that it is not allowed to fall below a desirable value, due to improper care and attention being given to the lighting system. Those who by reason of their experience are enabled to plan an illumination layout without direct reference to spacing tables, formulas, etc., should find this instrument of special value in securing data which can be applied in the designing of future installations.

A number of other types of illuminometers of somewhat more complex design are available, with which a higher degree of accuracy is possible than with the foot-candle meter.

109. The Candlepower Distribution Curve

The candlepower distribution curve of a lamp or unit was at one time widely used in calculating illumination intensities, but the greater simplicity and accuracy of the lumen method of computing illumination has resulted in the former method falling into disuse. Distribution curves are now used principally for comparing the suitability of reflectors for use in a given location from the standpoints, particularly, of light distribution and light absorption.

Fig. 5 presents three methods of showing the manner in which the candlepower of a unit measured at different angles can be recorded. The value at any angle represents the average candlepower of the source at that angle as the source rotates about its vertical axis. At the left of the figure the data are given in tabular form; at the center and the right they are plotted to polar coordinates. Distribution curves are used simply as a graphical method for presenting the data given in the table on the left. All

have exactly the same meaning. A distribution curve is a graphical —not a pictorial—representation of the light distribution from a source, although its general shape might convey the wrong impression. It is simply a convenient engineering method of presenting tabulated data graphically.

The area of a distribution curve is not a criterion of the total amount of light emitted by a source. In Fig. 6, both curves shown are taken from units giving exactly the same total lumens with different distributions of candlepower; although curve *B* appears from the distribution curve to represent much more light than *A*, the amount of light given off is the same in each case.

In calculating the flux of light in various zones, we usually find it convenient to calculate for zones of 10 degrees, and it is sufficiently accurate for most purposes to assume that the candlepower value at the center of each 10-degree zone represents the average

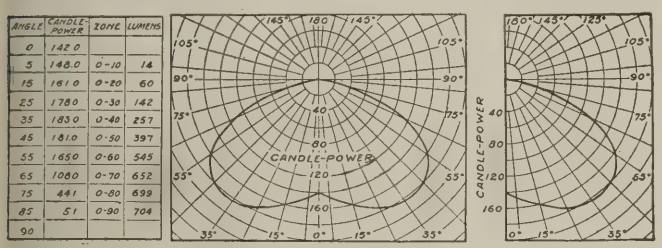


Fig. 5—Three Methods of Recording Candle Power Distribution Data

candlepower of the zone. The following are the factors by which such candlepower values should be multiplied to give the lumens in each 10-degree zone:

Zone	Factor to Obtain Lumens from Average C.P.
0°-10°	0.0954
10°-20°	0.283
20°-30°	0.463
30°-40°	0.628
40°-50°	0.774
50°-60°	0.897
60°-70°	0.992
70°-80°	1.058
80°-90°	1.091

Above 90 degrees the factors are the same but in the reverse order.

To use these factors with the curve of any light unit, we take the candlepower at 5 degrees and multiply it by the 0-10 degree factor to obtain the lumens in the 0-10 degree zone; we take the candlepower at 15 degrees and multiply it by the 10-20 degree zone factor to obtain the lumens in the 10-20 degree zone, etc. The total lumens for any large zone is the sum of the lumens thus determined in all of the 10-degree sections of the zone.

REFLECTORS AND ENCLOSING GLASSWARE

110. Systems of Lighting

The light from a bare incandescent lamp is distributed in such a manner that under most conditions it cannot be employed effectively without the use of reflectors or enclosing glassware. Such accessories should not only redirect light into useful angles which would otherwise be ineffective, but should serve the additional purposes of modifying the brilliancy of the light source and diffusing the light to produce a soft and pleasing illumination.

For general illumination, three systems of lighting are commonly employed. These systems are known as:

1. Direct lighting.
2. Indirect lighting.
3. Semi-indirect lighting.

110—1. With the direct lighting system the light is distributed directly downward upon the surfaces to be illuminated. The distribution of the light emanating from the lamp may, however, first be altered by means of reflectors or enclosing glassware. The direct and reflected glare which would result from the use of a bare lamp may also be modified by the use of an opal glass diffusing globe. The use of such a globe will also soften the resultant shadows.

110—2. In the totally indirect lighting system all of the light emitted from the unit is thrown first to the ceiling and from there diffused throughout the room. In such a system the ceiling acts as the light source, and the glare is reduced to a minimum. The resulting illumination is softer and more diffused, the shadows are less prominent, and the appearance of the room is much improved over that which results from direct lighting.

110—3. In the semi-indirect system of illumination, the features of both the direct and indirect systems are combined. A small portion of the light passes directly downward through the unit, lighting the room in a similar manner to the direct lighting system. The major portion of the light, however, is thrown to the ceiling and from there diffused throughout the room. Of course, with the last two named systems it is important that the ceilings be light in color in order that there may be a maximum efficiency of reflection.

111. Methods of Distributing Light

In designing these accessories which are to be used with the bare lamp, use is made of the four methods of altering the straight-line course of a ray of light. These four methods of interference are known as absorption, refraction, reflection and diffusion, and by the proper control and manipulation of these four factors the light from the bare lamp may be distributed as desired.

The simplest form of reflection is that which occurs when a ray of light strikes a polished metal surface. As indicated in Fig. 7-A, the ray of light upon striking the surface at *a*, is reflected off in the direction *ab*, so that the angle of incidence *x* equals the angle of reflection *y*. However, all of the light is not redirected along *ab*, since some of it is absorbed by the surface of the metal. All of the light falling upon an opaque surface is either reflected or absorbed by that surface.

Similar to the reflection characteristics of the polished metal are those of mirrored glass. Fig. 7-B shows the path of a ray of light striking the surface of a mirror having silvering on the back of the glass. A small portion of the light is reflected immediately upon striking the surface of the glass. The remainder is refracted or bent and passes through the glass to the silvered surface and is

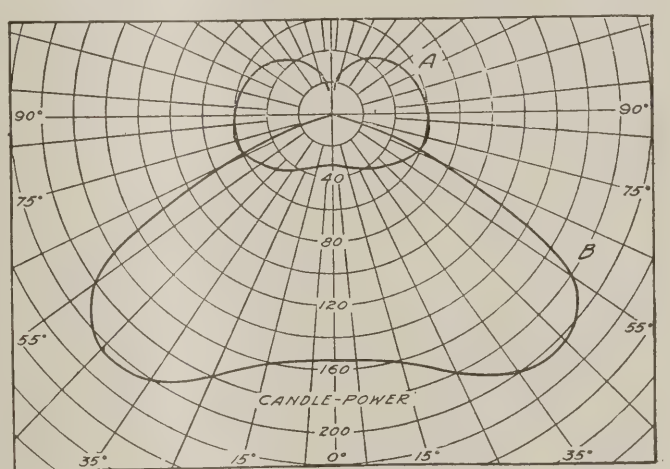


Fig. 6—The Area of a Distribution Curve Is Not a Criterion for Judging Light Output. These Two Curves Represent Equal Light Outputs

from there reflected back out through the glass. Of course, some of the light is absorbed by the glass and by the silver.

A dull-finished or semi-mat surface can be considered as one which has many small polished surfaces, making innumerable slight angles with the apparent contour. A surface coated with aluminum paint affords a good example. When a shaft of light strikes such a surface, a spread reflection such as is shown in Fig. 7-C results. Such reflections are more difficult to control than reflections from polished surfaces and require more careful designing as to shape of reflectors for efficient results. The aluminized-steel reflector is the only commercial semi-matt reflector in general use.

Another type of reflector is the prismatic glass reflector, which is made up of a carefully designed combination of small prisms which compose the entire body of the reflector. By means of triangular pieces of glass, known as prisms, the path of a ray of

light may be altered, either by reflection or refraction, as indicated in Figs. 7 E and F.

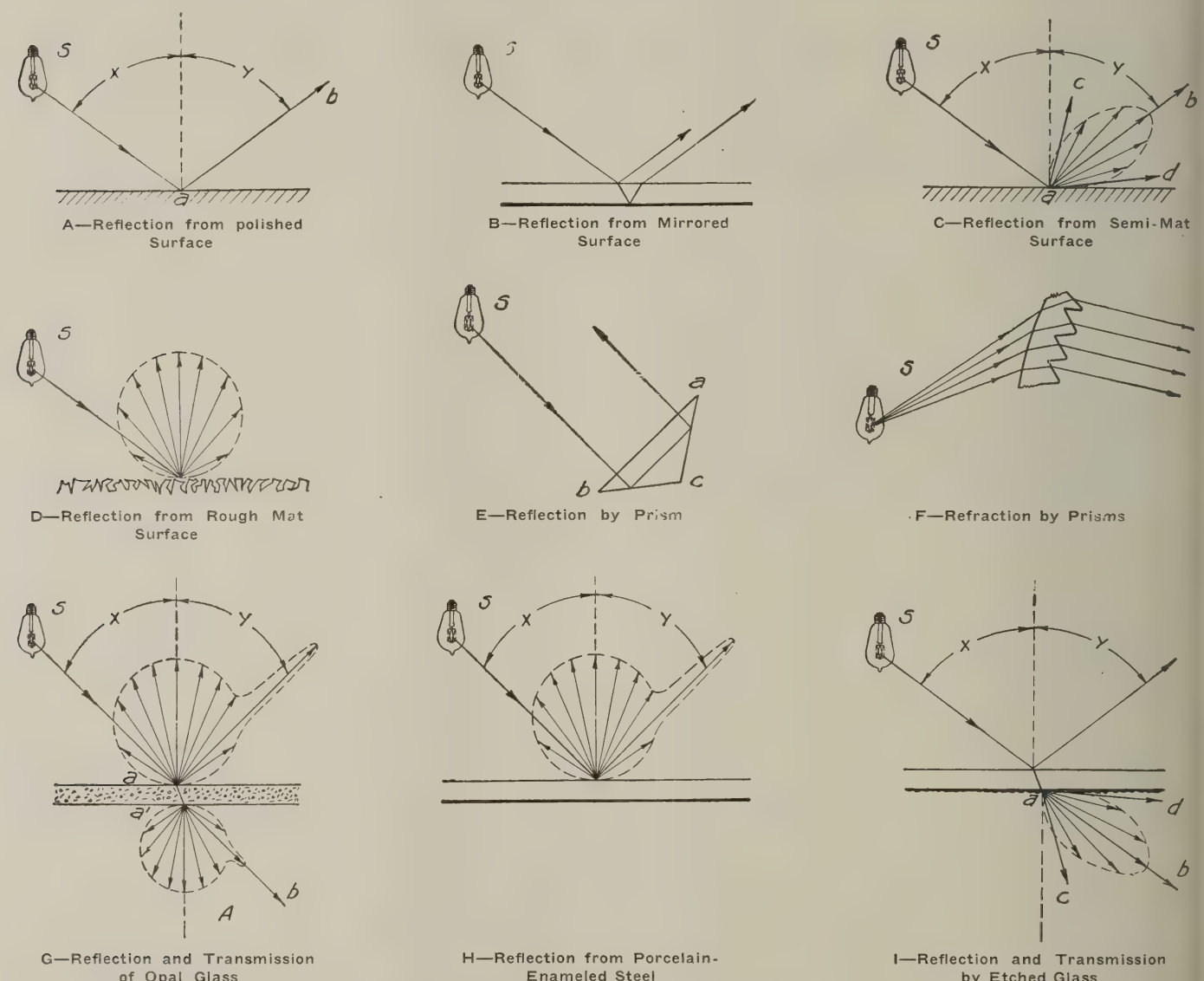
Opal glass finds considerable application in illumination practice, both as a reflecting and a transmitting medium. Opal glass may be regarded as a common glass in which fine white particles are held in suspension. When a ray of light strikes the surface, a portion, depending upon the density of the glass, is reflected as with polished metal. The remainder passes through the glass in straight lines until it strikes these white particles, which disperse it in all directions. Some is thrown back and reflected as shown in Fig. 7-G, while the remainder is transmitted through and out in all directions. Opal glass is a very desirable reflector material, since the smooth surface minimizes the collection of dirt and makes cleaning easy, and the glass transmits a portion of the light, rendering the reflector luminous and enhancing its appearance. This mission rather than as a good reflector. Unless a frosted glass is of very fine texture, it accumulates dirt very rapidly and is difficult to clean.

Diffusion of Light

In addition to a knowledge of reflecting surfaces and reflectors, a knowledge of such other factors as glare, shadow, and illumination of vertical surfaces—in a word, the diffusion of light—is necessary before an intelligent selection of a lighting system can be made. These factors all require most careful consideration if the best results are to be obtained.

112. Glare

A satisfactory definition of glare, it seems, has never yet been given. It has been variously defined as being "light out of place," "non-useful light," "light which causes interference with vision,"



A—Reflection from polished Surface

B—Reflection from Mirrored Surface

C—Reflection from Semi-Mat Surface

D—Reflection from Rough Mat Surface

E—Reflection by Prism

F—Refraction by Prisms

G—Reflection and Transmission of Opal Glass

H—Reflection from Porcelain-Enameled Steel

I—Reflection and Transmission by Etched Glass

Fig. 7—Effect of Various Media of Light Rays

glass is used in the manufacture of many of the commercial units in use today, both in direct and semi-indirect units.

The enameled metal or porcelain enameled steel reflector in common use today presents a surface which may be likened to a plate of dense opal glass in optical contact with a steel backing. Fig. 7-H shows the characteristic distribution of a porcelain enameled steel reflector. Porcelain enameled reflectors find their principal use in industrial plants, where the advantages of efficiency, ruggedness, and permanancy of reflecting surface are important.

Use is made of the frosted glass transmission characteristics as shown in Fig. 7-I, in frosted or bowl enameled lamps. This frosted or etched glass is used to give a spread or diffused trans-

etc. Suffice it to say that the element of glare in any lighting system is harmful and should ordinarily be strictly avoided. It is recognized, however, that under some special conditions its presence is necessary; as for instance, where glaring reflections are used to discern fine lines on polished surfaces. It is not to be expected, however, that such fine work will be encountered among the ordinary railroad operations.

Strictly speaking, there is but one source of glare, that resulting from the brightness of either light sources or objects. Various conditions of usage, however, are responsible for the various types of glare ordinarily encountered. With this in mind it is possible to analyze it by means of the following subdivisions:

112—1. Brightness of Source:
(a) High brightness.
(b) Low brightness.

112—2. Conditions of Use:
(a) Brightness contrast.
(b) Location in field of view.
(c) Total volume of light entering eye.

High brightness light sources cause glare when viewed even casually. A glance at the sun is all that is necessary to prove this statement. Sources of artificial light, such as the filament of incandescent lamps, whose brightness is much lower than that of the sun, are also sufficient to cause acute discomfort when viewed for a fraction of a second.

Objects possessing low brightness and which do not of themselves emit light, can also be glaring when viewed for a continued length of time. Furthermore, it is not necessary for such objects to be in the direct field of view, as is evidenced by the fact that an overcast sky or an unbroken expanse of light colored wall can prove as discomforting as a bright light source.

Conditions of using sources of artificial light give rise to the types of glare listed under Section 2; thus if a decided contrast in brightness exists between light source and its surroundings, the eye will be unable to accommodate itself to the two degrees of brightness. In order that the contrast may not be too great between the light source and its surroundings, it is the general practice to paint the walls and ceilings a light color. Then, in order to further reduce the brightness contrast in the direct field of view, a green dado is painted around the walls to a height of approximately four feet.

Toleration of bright light sources in the immediate vicinity is made possible by locating them at such a height as to place them above the ordinary range of vision, which general agreement fixes as being 14 degrees above the horizontal. As a further aid in protecting the eye from the direct rays of the source, metal reflectors for industrial lighting are ordinarily provided with a skirt around the rim of the reflector. Wherever conditions permit high hangings of units should be used, in order to reduce the likelihood of glare from this standpoint.

It is not possible, of course, to place all sources of light high enough in order to move them entirely from the direct range of normal vision. In such cases the size of the light source, in proportion to its distance from the observer, has an important bearing on the possibility of glare, since a 100-watt lamp in an opal glass bowl can cause as much discomfort if placed near the observer as a bare lamp located farther away. The determining factor here is the total volume of light entering the eye. Thus it is possible for a large light source of low brightness to provide as much light to the eye as a small filament of high brightness whose area is but a fraction of that of the globe. It is seldom that even the brightest light sources will prove glaring if located a considerable distance away from the observer. The best protection in cases where the sources must be placed on or below the level of the eye, is to shield the source by means of reflectors and shades, thus preventing the direct rays of light from reaching the eye.

113. Shadow

Contrary, perhaps, to popular opinion, a certain amount of shadow is desirable in artificial lighting. Objects illuminated by perfectly diffused light appear flat and uninteresting, contours are lost, and it is difficult for the eye to form a correct judgment of the shape of an object. On the other hand, deep, black shadows are troublesome and are a source of constant danger because of what they may conceal. Shadows having a sharp edge or a series of sharp edges, which result from several small light sources near one another, are particularly annoying in office work, where they dance about the pencil point most disconcertingly. In general, in interior lighting, only soft illuminated shadows with gradually fading outlines should be tolerated.

The number of shadows cast by an object and their length depends upon the number and the position of sources directing light toward the object; the softness of the shadow depends upon the area of the surfaces from which the light comes and upon the number of directions from which light is received. Indirect and dense semi-indirect units which make the ceiling serve as the principal light source, and large units of the direct-lighting type, therefore, make for soft shadows, small units of the direct type make for sharp shadows. As a general rule, lighting units which are satisfactory for application from the standpoints of light diffusion and low brightness will also prove satisfactory from the standpoint of shadow when a sufficient number are used to provide a satisfactory degree of uniformity in the lighting of the work.

114. Illumination of Horizontal and Vertical Surfaces

For many locations, such as offices and drafting rooms, light is required principally on horizontal planes, such as desk tops or table tops, and it has been the custom to calculate illumination on the basis of that delivered to horizontal surfaces with the assumption that the oblique surfaces of objects would be sufficiently lighted. This practice may result in inadequate illumination. In a machine shop, for example, the lighting of the vertical surfaces of the work or of machine parts is fully as important as the lighting of horizontal surfaces. As a matter of fact, most shops are lighted during the day only by light from windows, which give a greater light on the vertical surfaces than on the horizontal. In all such cases where direct lighting is used, only those lighting units should be installed which show a reasonably good candlepower in the 50-70 degree zone as well as below these angles. A shop lighted by closely spaced automobile headlights directing the light downward from the ceiling would furnish ample light on a horizontal plane but such lighting would be far from satisfactory. The dome porcelain-enameled steel reflector gives the types of distribution desired for this purpose.

115. Desirable Wall Brightness

The effectiveness of a lighting system depends not only on the effectiveness of the lighting unit, but on the reflecting properties of the walls, ceiling and surroundings, and upon the size and proportions of the room. It is, in fact, entirely possible to find an installation of reflectors of poor design and inferior from the standpoint of glare, which is nevertheless, from the single standpoint of the percentage of light reaching the illumination plane, better than an installation where reflectors of good design are used, if the former are installed under favorable conditions such as light walls, ceiling, etc., and the latter under unfavorable conditions. On the other hand, it must be borne in mind that a large expanse of wall surface finished so light as to reflect a large volume of light into the eye is objectionable for offices, and all rooms, where the occupants are likely to sit more or less directly facing the walls for considerable periods of time. Such data as are available indicate that where the brightness of the walls is equal to or greater than, the brightness of white paper lying on a table or desk, annoying glare will result. In fact, a wall brightness one-half that of the paper has been found unsatisfactory—a brightness of 20 per cent is, apparently, comfortable. With the usual types of lighting units, walls are not illuminated to intensities as high as those obtaining on desk or table tops, and walls which reflect less than 50 per cent of the light which strikes them should not produce discomfort providing, of course, that they are of a mat or semi-mat finish. Walls finished in buff, light green, or gray reflect about the proper proportion of light and their use is meeting with general favor. Walls finished in high gloss are not satisfactory from a glare standpoint.

Definite values for the efficiency of different types of units as they are used in practice are presented a little later in this part.

116. Maintenance

The experiences of those who have installed high levels of illumination prove conclusively that every footcandle delivered at the work has a definite tangible value.

The man who provides a system capable of delivering 10 footcandles at the work and then allows the system to depreciate due to dirt on the reflectors and lamps, until it delivers only 3 to 4, is losing not only 60 or 70 per cent of the light he is paying for but, what is far more important, he is losing the profit on the difference between the output of his employees at this low level of illumination and their output at the higher level. If the depreciation of a lighting system were of the order of 2 or 3 per cent or even 10 per cent the matter would not be such a serious one, but surveys of installations in service show depreciations of 50 per cent, 60 per cent, and more. Many users are not getting one-third of the light their systems are capable of delivering. The importance of frequent cleaning of the lighting equipment and renewal of lamps which have depreciated in candle power cannot be too strongly emphasized.

117. Illumination Design Data

To take the several essential factors entering into illumination design properly into account has appeared so complicated a task

that many designers have adhered to rule-of-thumb methods which, while adequate in some cases, are likely to lead to unsatisfactory results when applied generally.

A number of methods have been employed in determining the lamp wattage required in a given lighting system, the more common and satisfactory of which are the point by point method and the lumen method.

The point-by-point method consists in selecting a series of location points in the room and calculating the foot candles of each point from each light source using a candlepower distribution curve of the lighting units and the following formula:

$$\text{Horizontal foot candles} = \frac{CP \times \cos^2 a}{H^2}$$

The above symbols have the following meaning: "CP" refers to candlepower in that particular direction. "$\cos^2 a$" refers to the angle formed by the perpendicular distance from lighting unit to floor and the direct distance from lighting unit to illuminated point. "H" refers to the height of lighting unit above illuminated point.

A simpler formula which avoids the use of angles and logarithmic tables is as follows:

$$\text{Horizontal foot candles} = \frac{IH}{\sqrt{(H^2 + V^2 + L^2)^3}}$$

The symbols have the following meaning: "I" equals candlepower in the particular direction. "H" equals height of lighting unit above illuminated point. "V" equals horizontal distance measured perpendicularly from "H" to plane containing illuminated point. "L" equals horizontal distance from point where "V" strikes plane containing illuminated point to the illuminated point in question. This distance is measured at right angles to distance "V."

The point-by-point method can also be used for calculating the illumination on vertical surfaces by means of the following formula:

$$\text{Vertical foot candles} = \frac{IV}{\sqrt{(H^2 + V^2 + L^2)^3}}$$

The symbols in this formula have the same meaning as those described above.

If the horizontal foot candle intensity at any particular point is known, it is a simple matter to find the vertical foot candle intensity at the same point by means of the following formula:

$$\text{Vertical foot candles} = \frac{\text{Horizontal foot candles} \times V}{H}$$

If the vertical foot candles at any point are known, the horizontal foot candle intensity can be found by means of this formula:

$$\text{Horizontal foot candles} = \frac{\text{Vertical foot candles} \times H}{V}$$

The distances "H," "V" and "L" can easily be determined from either direct measurements made on the spot or from floor plans of the room. No angles of any kind need be considered, thus avoiding the use of logarithmic tables.

This method is very satisfactory for direct lighting systems except where reflection from the ceiling or sidewalls need be considered.

The lumen method of design here presented will be found fully as simple as any of the common short-cuts. It has the decided advantage that the technical considerations which are important as influencing the result and which require the experienced judgment of the engineer have been taken into account in the preparation of the charts and tables and therefore automatically receive due allowance in the lighting design. The data apply in interiors where standard types of reflecting equipment are used to obtain general lighting of substantially uniform intensity.

The four steps to be carried out in the design of a general lighting system for a room are:

1. Decide the foot candle illumination required.
2. Select the type of lighting unit best adapted to the location.
3. Determine the location of outlets, the mounting height and number of lighting units required.
4. Ascertain the size of lamp which will provide the foot candles desired.

117—1. Foot-Candle Illumination

Table 1 lists the foot-candle values, corresponding to present standards, for different classes of industrial operations, offices, etc. The desirable illumination varies rather widely, depending on the conditions in any particular installation, such as the accuracy of the operation and fineness of detail to be observed and the color of objects worked on or handled. The foot-candle values recommended in the table are the minimum to be adhered to if fully satisfactory lighting is to be assured. Under particular conditions considerably higher illumination is often desirable.

TABLE 1

PRESENT STANDARDS OF FOOT-CANDLES ILLUMINATION INTERIOR LIGHTING

	Foot-candles Suggested	Recommended Range
Cars—		
Baggage	4	3-8
Day coach, dining and Pullman	8	6-12
Mail—		
Bag racks	8	6-12
Letter cases	10	8-16
Storage	6	5-10
Street railway, subway	8	6-12
Piers	2	1-3
Office Buildings—		
General office	10	6-12
Private offices	10	6-12
File rooms	4	3-6
Stenographer and bookkeeping rooms	10	6-12
Drafting rooms	15	10-20
Vault	3	2-6
Elevator (freight and passenger)	3	2-4
Halls, passageways in interiors	2	2-5
Shops—		
Carpenter—		
Rough sawing and bench work	5	3-6
Sizing, planing, rough sanding, medium machine and bench work, gluing, veneering, cooperage	8	5-10
Fine bench and machine working, fine sanding and finishing	8	6-12
Electric repair	5	4-8
Storage battery, charging room	6	4-8
Coil and armature winding, mica working, insulating processes	10	8-16
Erecting	6	4-8
Forge and welding—		
Rough forging	6	4-8
Fine forging and welding	10	6-12
Foundries—		
Charging floor, tumbling, cleaning, pouring and shaking out	5	3-6
Fine molding and core making	10	6-12
Freight Car Repair—		
General illumination, floor area	2	1-5
Local work areas and around tools	6	4-8
Machine—		
Rough bench and machine work	6	4-8
Medium bench and machine work, ordinary automatic machines, rough grinding, medium buffing and polishing	10	6-12
Fine bench and machine work, fine automatic machines, medium grinding, and buffing and polishing	12	10-20
Extra fine bench and machine work, grinding (fine work)	—	10-50
Paint—		
Dipping, spraying, firing, rubbing, ordinary hand painting and finishing	8	5-10
Fine hand painting and finishing	10	8-16
Extra fine hand painting and finishing	15	10-50
Power House—		
Boilers, coal and ash handling, storage battery rooms	3	2-5
Auxiliary equipment, oil switches and transformers	5	5-10
Switch boards, engines, generators, blowers, compressors	6	5-10

Round Houses—		
Vertical illumination on running gear, etc..	5	4-8
Horizontal illumination on working areas.	4	3-8
Stations—		
Waiting room	4	3-8
Restaurant	6	4-8
Barber shop	8	5-10
Toilets and wash rooms	4	3-6
Freight	4	3-6
Store and Stock Rooms—		
Rough	3	2-5
Medium	6	4-8
Locker rooms	4	2-4
Warehouses	2	1-2
EXTERIOR LIGHTING		
Automobile parking spaces	0.5	0.25-1.00
Building—		
Construction work	3	2-5
Excavation	1	1-3
Coaling stations	2	1-4
Inside structure	1	1-3
Dredging	1	1-3
Docks	2	1-3
Protective	0.5	0.25-1.00
Railway Yards—		
General	0.15	0.025-0.50
Approach to hump	0.5	0.25-1.00
Turntables	1.0	0.5-2
Yard thoroughfares	0.5	0.25-2.00

117—2. Type of Lighting Unit

The selection of the type of lighting unit depends not only upon the requirements of the work, but in some cases upon the construction of the room and the color of ceiling and walls. For example, semi and totally indirect lighting is unsuited to rooms with very dark ceilings. It is important to specify the type of lamp to be used since, for example, as shown in Table 2, bowl-enameled lamps used in open reflectors, such as RLM standard domes, form a much superior lighting unit from the standpoint of glare, reflected glare, and shadows than clear lamp units of the same type. In general, clear Mazda C lamps should not be used in open reflectors where the mounting height is 20 feet or less.

Factors other than those listed in Table 2 may enter into the choice of the lighting unit in certain instances. For example, stations, offices and other public installations, decorative effect is often an important item. Table 2 rates the various types of units comparatively to serve as a basis for judgment of the adaptability of a unit for a particular class of installation.

117—3. Location of Outlets, Mounting Height, and Number of Lighting Units

Make a diagram to scale of the floor area of the room. If the units are of semi or totally indirect types, measure the ceiling height of room and refer to Table 3-b for the permissible spacing of units and preferred suspension distance of lighting units corresponding to this ceiling height.

If the units are of direct lighting type, determine the mounting height and refer to Table 3-a for the permissible spacing corresponding to this mounting height. If the units are mounted as close to the ceiling as possible (a minimum allowance of one foot is usually necessary to provide for the drop of the reflector from the ceiling) a wider spacing is permissible and fewer units are therefore necessary for an even distribution of light. Considerations of shadows, appearance and arrangement of work may make a lesser mounting height desirable even though a closer spacing of outlets would be needed to keep the same uniformity of illumination. Ordinarily lamps should not be mounted less than 10 feet above the floor unless a low ceiling makes it necessary.

Having determined the permissible spacing, proceed to locate the outlets on the diagram of the floor area. Locate the units as nearly symmetrically as possible without appreciably exceeding the permissible spacing for uniform illumination. At a greater height, a spacing closer than that in Table 3 results in greater freedom from shadows but increases the number of units required and makes the installation cost more. If a spacing somewhat closer than the permissible value is adopted, as is often the case, it is allowable, though not necessary, to refer back to Table 3 and select a lower mounting height corresponding to the new spacing.

The distance between the outside row of outlets and the wall should not exceed one-half the spacing distance. For office spaces, or where work is carried on at benches or machines near the wall, this distance should be approximately one-third the spacing distance.

117. 4. Lamp Size

After the outlets have been located on the plan, the lamp size to be used may be determined by the following calculation:

$$A \quad \text{Area in square feet per outlet} = \frac{\text{Total floor area in square feet}}{\text{Number of outlets}}$$

$$B \quad \text{Lamp lumens required per square foot} = \frac{\text{Foot-candles} \times \text{depreciation factor}}{\text{Coefficient of utilization}}$$

$$C \quad \text{Lamp lumens required for outlet} = \text{Area in square feet per outlet (From } A\text{)} \times \text{Lamp lumens required per square foot (From } B\text{)}$$

Foot-candles—Illumination decided upon.

Depreciation Factor—Use 1.3 for fairly clean locations. Use 1.5 for dirty locations or where cleaning is infrequent. This is the safety factor or allowance for depreciation due to aging of lamps, dirt, dust and deterioration of reflecting value of walls.

Coefficient of Utilization—The coefficient of utilization for the installation is determined as follows:

Table 5 shows that the coefficient of utilization varies according to the type of fixture, the proportions of the room expressed by "Room Index," and the color of the walls and ceiling. From the "Room Index" Table 4 find the room index corresponding most nearly to the dimensions of the installation. Then the coefficient of utilization for the installation of the type of lighting unit selected will be found from Table 5, in the proper column of wall and ceiling color opposite the correct room index. This is the proportion of the generated light from the lamps which reaches the plane of work.

Having determined the lamp lumens required per outlet by the above calculations, the wattage of lamps to be used may be found by reference to Table 6, which lists the lumen output rating for each size of Mazda and Mazda Daylight lamps. Locate in this table the size of lamp of the desired type which most nearly meets the requirements of lumen output. When the lamp lumens required fall nearly midway between two sizes, choose the larger rather than the smaller, unless it is certain that the less illumination from the smaller will suffice.

Computed Illumination Values

The foot-candles of illumination in service, allowing a depreciation factor of 1.3, obtained for systems having different coefficients of utilization and areas per lamp are worked out in Table 7. Table 7 can be referred to as an approximate check on design computations made as outlined above.

Choice of Reflecting Equipment

Various lighting units are rated in accordance with certain fundamentals. The importance of these criteria is different for different classes of work. It must be emphasized that the relative importance of the various criteria should be carefully weighed with respect to the particular problem at hand. For instance, in an office the criteria would rank in importance: (1) Direct glare; (2) Reflected glare; (3) Shadows; (4) Efficiency based upon illumination on horizontal; (5) Maintenance; (6) Vertical illumination. On the other hand, where lamps are to be hung above a crane in a foundry, the order of importance would be: (1) Efficiency base upon illumination on horizontal; (2) Vertical illumination; (3) Maintenance; (4) Shadows; (5) Direct glare; (6) Reflected glare.

In the chart the best rating given is A +, which denotes the highest degree of excellence, while D, the lowest, indicates that an installation of units so rated in any particular, will very likely prove unsatisfactory in an installation where this factor is important. The ratings B and C, while indicating a result not equal to A, are decidedly superior to rating D. In other words, a rating B, C + or C in certain respects does not disqualify a unit provided that in the essential requirements of a given location, the unit is rated A or B +.

A +	Excellent	B +	Good	C +	Fair	D Very Bad
A		B		C		
A —		B —		C —		

(*Continued on page* 328)

TABLE 2

A GUIDE TO THE SELECTION OF REFLECTING EQUIPMENT

	LIGHTING UNIT		EFFICIENCY BASED UPON: ILLUMINATION ON HORIZONTAL	EFFICIENCY BASED UPON: ILLUMINATION ON VERTICAL	FAVORABLE APPEARANCE OF LIGHTED ROOM	DIRECT GLARE	REFLECTED GLARE	SHADOWS	MAINTENANCE
	DIRECT LIGHTING PORCELAIN ENAMEL REFLECTORS								
1	R L M DOME Clear Lamp	90° to 180°—0% 0° to 90°—76%	A+	B+	C+	C	D	C+	A+
2	R L M DOME Bowl-Enameled Lamp	90° to 180°—0% 0° to 90°—66%	A−	B	B	B+	B	B+	A−
3	GLASSTEEL DIFFUSER	90° to 180°—7% 0° to 90°—60%	B+	B	A−	A−	B+	A−	B+
4	DEEP BOWL Clear Lamp	90° to 180°—0% 0° to 90°—65%	B+	B−	C	C+	D	C	A
5	DEEP BOWL Bowl-Enameled Lamp	90° to 180°—0% 0° to 90°—58%	B	C+	C	B	C+	C+	B+
6	FLAT CONE Shielding Band Clear Lamp	90° to 180°—1% 0° to 90°—54%	B	C+	C+	C+	D	C	B+
7	FLAT CONE Clear Lamp	90° to 180°—10% 0° to 90°—74%	B	B	C	D	D	C	A+
	DIRECT LIGHTING OPEN GLASS REFLECTORS								
8	LIGHT DENSITY OPAL Clear Lamp	90° to 180°—33% 0° to 90°—54%	B+	B	B+	C+	D	B−	B
9	LIGHT DENSITY OPAL Bowl-Enameled Lamp	90° to 180°—36% 0° to 90°—45%	B	B−	A−	B−	B−	B+	B−
10	DENSE OPAL Clear Lamp	90° to 180°—15% 0° to 90°—67%	A+	B+	B+	B	D	C+	A−
11	DENSE OPAL Bowl-Enameled Lamp	90° to 180°—16% 0° to 90°—60%	B+	B−	A−	B+	B−	B	B
12	MIRRORED GLASS Clear Lamp	90° to 180°—0% 0° to 90°—68%	A	B	C	C+	D	C	A−
13	MIRRORED GLASS Bowl-Enameled Lamp	90° to 180°— 0% 0° to 90°—55%	B	C+	C	B−	C	C+	B−
14	PRISMATIC INDUSTRIAL Clear Lamp	90° to 180°—18% 0° to 90°—73%	A+	A−	B+	C+	D	C+	B−

TABLE 2

A GUIDE TO THE SELECTION OF REFLECTING EQUIPMENT

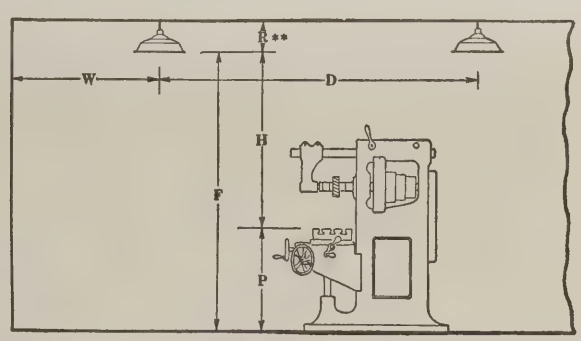
	LIGHTING UNIT		EFFICIENCY BASED UPON: ILLUMINATION ON HORIZONTAL	EFFICIENCY BASED UPON: ILLUMINATION ON VERTICAL	FAVORABLE APPEARANCE OF LIGHTED ROOM	DIRECT GLARE	REFLECTED GLARE	SHADOWS	MAINTENANCE
	DIRECT LIGHTING ENCLOSING AND SEMI-ENCLOSING UNITS								
15	DIFFUSING GLOBE Light Opal	90° to 180°—35% 0° to 90°—40%	B−	B−	A	B−	B	B+	B+
16	ONE-PIECE OPAL Flattened Reflecting Top	90° to 180°—35% 0° to 90°—45%	B	B	A	B	B	A−	A−
17	PRISMATIC ENCLOSING	90° to 180°—27% 0° to 90°—59%	B+	B	A	B	B−	B+	B
18	SEMI-ENCLOSING Metal Reflector	90° to 180°—20% 0° to 90°—56%	B	B	A	B	B	B+	B−
19	SEMI-ENCLOSING Compo Reflector	90° to 180°—13% 0° to 90°—60%	B	B	A	A	A−	A−	C+
20	TWO-PIECE GLASS Opal Refl and Enam Bowl	90° to 180°—12% 0° to 90°—53%	B	B	A	B+	B+	A−	B
21	ONE-PIECE GLASS Enameled Refl and Bowl	90° to 180°—22% 0° to 90°—50%	B	B	A	B+	B	A−	A−
	SEMI-INDIRECT AND INDIRECT LIGHTING UNITS								
22	LIGHT OPAL	90° to 180°—60% 0° to 90°—25%	B−	C+	A	B+	B+	A−	C
23	DENSE OPAL (or Light Opal and Bowl-Enameled Lamp)	90° to 180°—70% 0° to 90°—10%	C+	C	A	A+	A	A+	C
24	ENAMELED METAL REFLECTOR Opal Glass Bottom	90° to 180°—69% 0° to 90°—6%	C+	C	A	A+	A	A+	C
25	PRISMATIC ENCLOSED	90° to 180°—57% 0° to 90°—26%	B−	C+	A	A−	A−	A−	B
26	CLEAR TOP ENCLOSED Enameled Glass	90° to 180°—54% 0° to 90°—21%	C+	C	A	A+	A	A	B
27	MIRRORED INDIRECT	90° to 180°—80% 0° to 90°—0%	C+	C	B+*	A+	A	A+	C
28	ENAMELED METAL INDIRECT	90° to 180°—74% 0° to 90°—0%	C	C	B+	A+	A	A+	C

*For Luminous Bowl Type Rate A.

TABLE 3-A SPACING—MOUNTING HEIGHT

Direct Lighting Units, Including Semi-Enclosing and Totally Enclosing Units, No. 1 to No. 21

Mounting Height of Unit		Permissible Distance Between Outlets	Permissible Distance Between Outlets and Sidewalls	
Above Plane of Work	Above Floor*		In Usual Locations Where Aisles and Storage are Next to Wall	In Offices or Where Work Benches are Next to Wall
(H)	(F)	(D)	(W)	(W)
4	6½	6	3	2
5	7½	7½	3½	2½
6	8½	9	4½	3
7	9½	10½	5	3½
8	10½	12	6	4
9	11½	13½	6½	4½
10	12½	15	7½	5
11	13½	16½	8	5½
12	14½	18	9	6
13	15½	19½	9½	6½
14	16½	21	10½	7
15	17½	22½	11	7½
16	18½	24	12	8
18	20½	27	13½	9
20	22½	30	15	10
22	24½	33	16½	11
24	26½	36	18	12
27	29½	40½	20	13½
30	32½	45	22½	15
35	37½	52½	26	17½
40	42½	60	30	20



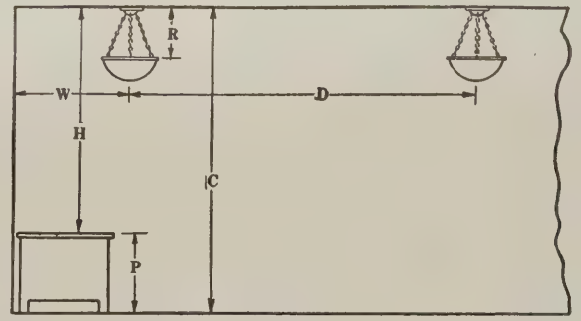
* Plane of work (P) assumed to be 2½ feet above floor. When the plane of work is higher or lower than 2½ feet above floor, neglect column (F) and work from column (H).

** Minimum allowance for (R) usually 1 foot.

TABLE 3-b SPACING—MOUNTING HEIGHT

Semi and Totally Indirect Lighting Units, No. 22 to No. 28

Ceiling Height		Permissible Spacing Distance Between Outlets	Permissible Distance Between Outlets and Sidewalls		Suspension Distance Ceiling to Top of Reflector**
Above Plane of Work	Above Floor*		In Usual Locations Where Aisles and Storage are Next to Wall	In Offices or Where Work Benches are Next to Wall	
(H)	(C)	(D)	(W)	(W)	(R)
5	7½	7½	3½	2½	1¼
6	8½	9	4½	3	1½
7	9½	10½	5	3½	1¾
8	10½	12	6	4	2
9	11½	13½	6½	4½	2¼
10	12½	15	7½	5	2½
11	13½	16½	8	5½	2¾
12	14½	18	9	6	3
13	15½	19½	9½	6½	3¼
14	16½	21	10½	7	3½
15	17½	22½	11	7½	3¾
16	18½	24	12	8	4
18	20½	27	13½	9	4½
21	23½	31½	15½	10½	5¼
24	26½	36	18	12	6
27	29½	40½	20	13½	6¾
30	32½	45	22½	15	7½
35	37½	52½	26	17½	8¾
40	42½	60	30	20	10



* Plane of work (P) assumed to be 2½ feet above floor. When the plane of work is higher or lower than 2½ feet above floor, neglect column (C) and work from column (H).

** Suspension distances (R) in Table are based on best distribution of light and efficiency of utilization for standard units. In some installations other considerations may require a different suspension distance.

TABLE No. 4—ROOM INDEX

Classify the room according to the proportions and the mounting height above the plane of work. Use upper column headings for direct-lighting units; for semi-indirect and totally indirect units choose column at bottom of page. Wherever the circumstances are such that the room index falls between two given figures, interpolate or use the smaller number.

Room Width	Room Length	DIRECT LIGHTING UNITS—Height Above Plane of Work — Feet													
Feet	Feet	4	5	6	7	8	9	10	12	14	16	20	24	30	40
	10	1.0	0.8	0.8	0.6	0.6	0.6	0.6	...	...	...	...	...	...	...
	12	1.25	0.8	0.8	0.6	0.6	0.6	0.6	...	...	...	...	...	...	...
8	16	1.25	1.0	0.8	0.6	0.6	0.6	0.6	...	...	...	...	...	...	...
	24	1.5	1.25	1.0	0.8	0.6	0.6	0.6	0.6	0.6	...	...	...	...	...
	35	1.5	1.25	1.25	1.0	0.8	0.8	0.6	0.6	0.6	0.6	...	...	...	...
	50	2.0	1.5	1.25	1.0	1.0	0.8	0.8	0.6	0.6	0.6	...	...	...	...
	10	1.25	1.0	0.8	0.6	0.6	0.6	0.6	...	...	...	...	...	...	...
	14	1.5	1.0	1.0	0.8	0.6	0.6	0.6	0.6	...	...	...	...	...	...
	20	1.5	1.25	1.0	0.8	0.8	0.6	0.6	0.6	0.6	...	...	...	...	...
10	30	2.0	1.5	1.25	1.0	0.8	0.8	0.6	0.6	0.6	0.6	...	...	...	...
	40	2.0	1.5	1.5	1.25	1.0	1.0	0.8	0.6	0.6	0.6	0.6	...	...	...
	70	2.0	1.5	1.5	1.25	1.25	1.0	1.0	0.8	0.8	0.6	0.6	...	...	...
	12	1.5	1.25	1.0	0.8	0.8	0.6	0.6	0.6	...	...	...	...	...	...
	18	1.5	1.25	1.25	1.0	0.8	0.8	0.6	0.6	0.6	...	...	...	...	...
	24	2.0	1.5	1.25	1.0	1.0	0.8	0.8	0.6	0.6	0.6	...	...	...	...
12	35	2.0	1.5	1.5	1.25	1.0	1.0	0.8	0.6	0.6	0.6	0.6	...	...	...
	50	2.0	2.0	1.5	1.5	1.25	1.0	1.0	0.8	0.6	0.6	0.6	0.6	...	...
	90	2.0	2.0	1.5	1.5	1.25	1.25	1.25	1.0	0.8	0.8	0.6	0.6	...	...
	14	1.5	1.5	1.25	1.0	0.8	0.8	0.6	0.6	0.6	...	...	...	...	...
	24	2.0	1.5	1.5	1.25	1.0	1.0	0.8	0.6	0.6	0.6	...	...	...	...
14	40	2.5	2.0	1.5	1.5	1.25	1.0	1.0	0.8	0.6	0.6	0.6	0.6	...	...
	70	2.5	2.0	2.0	1.5	1.5	1.25	1.25	1.0	0.8	0.8	0.6	0.6	...	...
	100	2.5	2.0	2.0	1.5	1.5	1.5	1.5	1.25	0.8	0.8	0.6	0.6	...	...
	16	2.0	1.5	1.25	1.25	1.0	0.8	0.8	0.6	0.6	0.6	...	...	...	...
	30	2.5	2.0	1.5	1.5	1.25	1.0	1.0	0.8	0.6	0.6	0.6	...	...	...
16	50	2.5	2.0	2.0	1.5	1.5	1.25	1.25	1.0	0.8	0.6	0.6	0.6	0.6	...
	80	2.5	2.0	2.0	2.0	2.0	1.5	1.5	1.25	1.0	0.8	0.6	0.6	0.6	...
	120	2.5	2.0	2.0	2.0	2.0	1.5	1.5	1.5	1.0	1.0	0.8	0.8	0.6	...
	18	2.0	2.0	1.5	1.25	1.0	1.0	0.8	0.8	0.6	0.6	...	...	...	...
	35	3.0	2.5	2.0	1.5	1.5	1.25	1.0	1.0	0.8	0.6	0.6	0.6	...	...
18	50	3.0	2.5	2.0	2.0	1.5	1.5	1.25	1.0	0.8	0.8	0.6	0.6	0.6	...
	80	3.0	2.5	2.0	2.0	2.0	1.5	1.5	1.25	1.0	0.8	0.8	0.6	0.6	...
	120	3.0	2.5	2.0	2.0	2.0	1.5	1.5	1.5	1.25	1.0	0.8	0.8	0.6	...
	20	2.5	2.0	1.5	1.5	1.25	1.0	1.0	0.8	0.6	0.6	0.6	...	...	...
	40	3.0	2.5	2.0	2.0	1.5	1.5	1.25	1.0	0.8	0.8	0.6	0.6	...	...
20	60	3.0	2.5	2.5	2.0	2.0	1.5	1.5	1.25	1.0	0.8	0.6	0.6	0.6	0.6
	100	3.0	2.5	2.5	2.0	2.0	2.0	1.5	1.5	1.25	1.0	0.8	0.6	0.6	0.6
	140	3.0	2.5	2.5	2.0	2.0	2.0	1.5	1.5	1.25	1.25	1.0	0.8	0.6	0.6
	24	3.0	2.5	2.0	1.5	1.5	1.25	1.25	1.0	0.8	0.8	0.6	0.6	...	...
	50	3.0	3.0	2.5	2.0	2.0	1.5	1.5	1.25	1.0	1.0	0.8	0.6	0.6	...
24	70	3.0	3.0	2.5	2.5	2.0	2.0	1.5	1.5	1.25	1.0	0.8	0.6	0.6	0.6
	100	3.0	3.0	2.5	2.5	2.0	2.0	2.0	1.5	1.5	1.25	1.0	0.8	0.6	0.6
	160	3.0	3.0	2.5	2.5	2.0	2.0	2.0	1.5	1.5	1.5	1.25	1.0	0.8	0.6
	30	4.0	3.0	2.5	2.0	2.0	1.5	1.5	1.25	1.0	1.0	0.8	0.6	0.6	...
	60	4.0	3.0	3.0	2.5	2.5	2.0	2.0	1.5	1.25	1.25	1.0	0.8	0.6	0.6
30	100	4.0	3.0	3.0	3.0	2.5	2.5	2.0	2.0	1.5	1.5	1.0	0.8	0.6	0.6
	140	4.0	3.0	3.0	3.0	2.5	2.5	2.0	2.0	2.0	1.5	1.25	1.0	0.8	0.6
	35	4.0	3.0	3.0	2.5	2.0	2.0	1.5	1.5	1.25	1.0	0.8	0.6	0.6	...
	70	5.0	4.0	3.0	3.0	3.0	2.5	2.0	2.0	1.5	1.5	1.0	0.8	0.6	0.6
35	100	5.0	4.0	3.0	3.0	3.0	2.5	2.5	2.0	2.0	1.5	1.25	1.0	0.8	0.6
	140	5.0	4.0	3.0	3.0	3.0	2.5	2.5	2.0	2.0	1.5	1.5	1.25	0.8	0.6
	40	5.0	4.0	3.0	3.0	2.5	2.0	2.0	1.5	1.5	1.25	1.0	0.8	0.6	0.6
40	80	5.0	4.0	3.0	3.0	3.0	2.5	2.5	2.0	2.0	1.5	1.25	1.0	0.8	0.6
	140	5.0	4.0	3.0	3.0	3.0	2.5	2.5	2.5	2.0	2.0	1.5	1.25	1.0	0.8
	50	5.0	5.0	4.0	4.0	3.0	2.5	2.5	2.0	2.0	1.5	1.25	1.0	0.8	0.6
50	100	5.0	5.0	4.0	4.0	3.0	3.0	3.0	2.5	2.5	2.0	1.5	1.25	1.0	0.8
	200	5.0	5.0	4.0	4.0	3.0	3.0	3.0	2.5	2.5	2.5	2.0	1.5	1.25	1.0
	60	5.0	5.0	5.0	4.0	4.0	3.0	3.0	2.5	2.0	2.0	1.5	1.25	1.0	0.8
60	100	5.0	5.0	5.0	5.0	4.0	4.0	3.0	3.0	2.5	2.0	1.5	1.5	1.25	1.0
	200	5.0	5.0	5.0	5.0	4.0	4.0	3.0	3.0	3.0	2.5	2.0	2.0	1.5	1.0
	70	5.0	5.0	5.0	5.0	4.0	4.0	3.0	3.0	2.5	2.0	1.5	1.5	1.25	0.8
70	140	5.0	5.0	5.0	5.0	5.0	4.0	4.0	3.0	3.0	3.0	2.0	2.0	1.5	1.0
	200	5.0	5.0	5.0	5.0	5.0	4.0	4.0	3.0	3.0	3.0	2.5	2.0	1.5	1.25
	80	5.0	5.0	5.0	5.0	5.0	4.0	4.0	4.0	3.0	2.5	2.0	1.5	1.25	1.0
80	140	5.0	5.0	5.0	5.0	5.0	5.0	4.0	4.0	3.0	3.0	3.0	2.5	2.0	1.25
	100	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.0	4.0	3.0	2.5	2.0	1.5	1.25
100	200	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.0	4.0	3.0	3.0	2.5	2.0	1.5
	120	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.0	4.0	3.0	2.5	2.0	1.5
120	200	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.0	3.0	3.0	2.5	1.5
		6	7½	9	10½	12	13½	15	18	21	24	30	36	45	60

Feet

SEMI AND INDIRECT LIGHTING UNITS—Ceiling Height Above Plane of Work

TABLE 5—COEFFICIENTS OF UTILIZATION

Find *Room Index* from Table 4. Check Reflection Factors on Color Chart

DIRECT LIGHTING PORCELAIN ENAMEL REFLECTORS

	COLOR REFLECTION FACTOR	CEILING	VERY LIGHT (70%)			FAIRLY LIGHT (50%)			FAIRLY DARK (30%)	
		WALLS	FAIRLY LIGHT (50%)	FAIRLY DARK (30%)	VERY DARK (10%)	FAIRLY LIGHT (50%)	FAIRLY DARK (30%)	VERY DARK (10%)	FAIRLY DARK (30%)	VERY DARK (10%)
	REFLECTOR TYPE	ROOM INDEX	COEFFICIENTS OF UTILIZATION							
1	R L M DOME Clear Lamp 90° to 180°—0% 0° to 90°—76%	0.6	.34	.29	.24	.34	.29	.24	.28	.24
		0.8	.42	.38	.34	.42	.37	.33	.37	.33
		1.0	.46	.43	.39	.45	.42	.39	.42	.39
		1.25	.50	.47	.43	.49	.46	.43	.45	.42
		1.5	.53	.50	.46	.52	.49	.46	.48	.45
		2.0	.58	.55	.51	.57	.54	.51	.53	.51
		2.5	.62	.59	.56	.61	.58	.56	.58	.56
		3.0	.64	.61	.58	.63	.60	.58	.60	.58
		4.0	.67	.65	.63	.66	.64	.62	.63	.61
		5.0	.69	.67	.65	.67	.66	.64	.65	.63
2	R L M DOME Bowl-Enameled Lamp 90° to 180°—0% 0° to 90°—66%	0.6	.32	.28	.25	.32	.28	.25	.27	.25
		0.8	.40	.36	.34	.39	.35	.33	.35	.33
		1.0	.43	.39	.37	.42	.39	.37	.39	.37
		1.25	.46	.43	.41	.45	.43	.41	.43	.41
		1.5	.48	.45	.43	.47	.45	.43	.45	.43
		2.0	.52	.50	.48	.51	.49	.47	.49	.47
		2.5	.56	.54	.52	.55	.53	.51	.53	.51
		3.0	.57	.55	.53	.56	.54	.52	.54	.52
		4.0	.60	.58	.56	.59	.57	.55	.57	.55
		5.0	.61	.59	.57	.60	.58	.57	.58	.56
3	GLASSTEEL DIFFUSER 90° to 180°—7% 0° to 90°—60%	0.6	.29	.25	.21	.28	.24	.21	.23	.21
		0.8	.36	.32	.29	.35	.31	.28	.31	.28
		1.0	.39	.36	.33	.38	.35	.33	.34	.32
		1.25	.42	.39	.36	.41	.38	.36	.37	.35
		1.5	.45	.42	.39	.43	.40	.38	.39	.38
		2.0	.49	.46	.43	.48	.45	.43	.44	.42
		2.5	.53	.50	.47	.51	.49	.47	.47	.46
		3.0	.54	.52	.49	.52	.50	.49	.49	.47
		4.0	.57	.55	.53	.55	.53	.51	.51	.50
		5.0	.58	.56	.54	.56	.54	.53	.52	.51
4	DEEP BOWL Clear Lamp 90° to 180°—0% 0° to 90°—65%	0.6	.31	.26	.23	.30	.26	.23	.25	.23
		0.8	.38	.34	.31	.37	.34	.31	.33	.31
		1.0	.41	.38	.35	.41	.38	.35	.37	.35
		1.25	.44	.41	.38	.44	.41	.38	.40	.38
		1.5	.47	.44	.41	.46	.43	.41	.43	.41
		2.0	.51	.48	.45	.50	.47	.45	.47	.45
		2.5	.54	.51	.49	.53	.51	.49	.51	.49
		3.0	.56	.54	.51	.55	.53	.51	.53	.51
		4.0	.58	.56	.54	.57	.55	.54	.55	.53
		5.0	.60	.58	.56	.58	.57	.55	.56	.55
5	DEEP BOWL Bowl-Enameled Lamp 90° to 180°—0% 0° to 90°—58%	0.6	.29	.26	.23	.29	.26	.23	.25	.23
		0.8	.35	.33	.31	.35	.32	.30	.32	.30
		1.0	.38	.36	.34	.38	.36	.34	.35	.34
		1.25	.41	.39	.37	.41	.39	.37	.38	.37
		1.5	.44	.41	.39	.43	.41	.39	.40	.39
		2.0	.47	.45	.43	.46	.44	.43	.43	.43
		2.5	.50	.48	.46	.49	.47	.46	.46	.46
		3.0	.51	.49	.47	.50	.48	.47	.47	.47
		4.0	.53	.51	.50	.52	.50	.49	.49	.49
		5.0	.54	.52	.51	.53	.51	.50	.50	.49
6	FLAT CONE Shielding Band Clear Lamp 90° to 180°—1% 0° to 90°—54%	0.6	.27	.23	.21	.26	.23	.21	.23	.21
		0.8	.32	.30	.28	.32	.29	.27	.29	.27
		1.0	.35	.33	.31	.35	.33	.31	.32	.31
		1.25	.38	.36	.34	.37	.36	.34	.35	.34
		1.5	.40	.38	.36	.39	.37	.36	.37	.36
		2.0	.43	41	.39	.42	.41	.39	.40	.39
		2.5	.46	44	.42	.45	.43	.42	.43	.42
		3.0	.47	.45	.43	.46	.44	.43	.44	.43
		4.0	.49	.47	.46	.48	.46	.45	.46	.45
		5.0	.50	.48	.47	.49	.47	.46	.47	.46
7	FLAT CONE Clear Lamp 90° to 180°—10% 0° to 90°—74%	0.6	.26	.20	.16	.26	.19	.16	.19	.16
		0.8	.32	.26	.22	.32	.26	.22	.26	.22
		1.0	.36	.30	.26	.36	.30	.26	.30	.26
		1.25	.41	.35	.30	.39	.34	.30	.33	.30
		1.5	44	.38	.33	.42	.37	.33	.36	.33
		2.0	.50	44	.38	.48	.43	.38	.42	.38
		2.5	.54	48	42	.52	.47	.42	.46	.42
		3.0	.57	.51	.46	.55	.50	.45	.49	.45
		4.0	.62	.56	.51	.60	.54	.50	.53	.50
		5.0	.65	.60	.54	.62	.56	.53	.55	.53

TABLE 5—COEFFICIENTS OF UTILIZATION

Find *Room Index* from Table 4. Check Reflection Factors on Color Chart

DIRECT LIGHTING OPEN GLASS REFLECTORS

	COLOR REFLECTION FACTOR	CEILING	VERY LIGHT (70%)			FAIRLY LIGHT (50%)			FAIRLY DARK (30%)	
	WALLS		FAIRLY LIGHT (50%)	FAIRLY DARK (30%)	VERY DARK (10%)	FAIRLY LIGHT (50%)	FAIRLY DARK (30%)	VERY DARK (10%)	FAIRLY DARK (30%)	VERY DARK (10%)
	REFLECTOR TYPE	ROOM INDEX	COEFFICIENTS OF UTILIZATION							
8	LIGHT DENSITY OPAL Clear Lamp 90° to 180°—33% 0° to 90°—54%	0.6	.26	.21	.17	.24	.19	.16	.18	.15
		0.8	.32	.27	.23	.30	.25	.22	.24	.21
		1.0	.36	.31	.27	.34	.29	.26	.27	.24
		1.25	.40	.35	.31	.37	.32	.29	.30	.27
		1.5	.44	.38	.34	.40	.35	.32	.32	.30
		2.0	.49	.44	.39	.45	.40	.37	.37	.34
		2.5	.53	.48	.44	.49	.44	.41	.40	.38
		3.0	.56	.51	.47	.51	.46	.43	.42	.40
		4.0	.60	.55	.51	.55	.50	.47	.46	.44
		5.0	.62	.58	.54	.57	.53	.50	.48	.46
9	LIGHT DENSITY OPAL Bowl-Enameled Lamp 90° to 180°—36% 0° to 90°—45%	0.6	.22	.17	.14	.20	.16	.13	.14	.12
		0.8	.27	.22	.19	.25	.21	.18	.19	.16
		1.0	.31	.26	.23	.28	.24	.21	.22	.19
		1.25	.35	.30	.26	.31	.27	.24	.24	.22
		1.5	.38	.33	.29	.34	.30	.26	.27	.24
		2.0	.43	.38	.34	.38	.34	.31	.30	.28
		2.5	.47	.42	.38	.42	.38	.34	.34	.31
		3.0	.49	.44	.40	.44	.40	.37	.36	.33
		4.0	.53	.49	.45	.48	.44	.41	.39	.37
		5.0	.56	.52	.48	.50	.46	.43	.40	.39
10	DENSE OPAL Clear Lamp 90° to 180°—15% 0° to 90°—67%	0.6	.32	.27	.23	.31	.26	.22	.25	.22
		0.8	.40	.35	.31	.38	.34	.31	.33	.30
		1.0	.44	.39	.36	.42	.38	.35	.37	.35
		1.25	.47	.43	.40	.46	.42	.39	.40	.38
		1.5	.51	.47	.43	.49	.45	.42	.43	.41
		2.0	.56	.52	.48	.54	.50	.47	.48	.46
		2.5	.60	.56	.53	.57	.54	.52	.52	.50
		3.0	.63	.59	.55	.60	.56	.54	.54	.52
		4.0	.66	.63	.60	.63	.60	.58	.57	.55
		5.0	.67	.65	.62	.65	.61	.59	.59	.57
11	DENSE OPAL Bowl-Enameled Lamp 90° to 180°—16% 0° to 90°—60%	0.6	.29	.24	.20	.28	.23	.20	.22	.20
		0.8	.35	.31	.28	.34	.30	.27	.29	.27
		1.0	.39	.35	.32	.38	.34	.32	.33	.31
		1.25	.43	.39	.36	.41	.38	.35	.36	.34
		1.5	.46	.42	.38	.44	.40	.37	.38	.36
		2.0	.51	.47	.44	.48	.45	.42	.43	.41
		2.5	.55	.51	.48	.52	.49	.46	.47	.45
		3.0	.57	.54	.50	.54	.51	.48	.48	.46
		4.0	.60	.57	.54	.57	.54	.52	.51	.50
		5.0	.62	.59	.56	.58	.56	.54	.53	.52
12	MIRRORED GLASS Clear Lamp 90° to 180°—0% 0° to 90°—68%	0.6	.32	.27	.24	.31	.27	.24	.27	.24
		0.8	.39	.35	.32	.39	.35	.32	.35	.32
		1.0	.43	.39	.37	.42	.39	.37	.39	.37
		1.25	.46	.43	.40	.46	.43	.40	.42	.40
		1.5	.49	.46	.43	.48	.45	.43	.45	.43
		2.0	.53	.50	.48	.52	.50	.48	.49	.48
		2.5	.57	.54	.52	.56	.54	.52	.53	.52
		3.0	.58	.56	.54	.57	.55	.54	.54	.53
		4.0	.61	.59	.57	.60	.58	.56	.57	.56
		5.0	.63	.61	.58	.61	.59	.58	.58	.57
13	MIRRORED GLASS Bowl-Enameled Lamp 90° to 180°—0% 0° to 90°—55%	0.6	.26	.22	.19	.25	.22	.19	.21	.19
		0.8	.32	.29	.26	.31	.28	.26	.28	.26
		1.0	.35	.32	.30	.34	.32	.30	.31	.30
		1.25	.38	.35	.33	.37	.35	.33	.34	.33
		1.5	.40	.37	.35	.39	.37	.35	.36	.35
		2.0	.43	.41	.39	.42	.40	.39	.40	.39
		2.5	.46	.44	.42	.45	.43	.42	.43	.42
		3.0	.47	.46	.44	.46	.45	.44	.44	.43
		4.0	.49	.48	.46	.48	.47	.46	.46	.45
		5.0	.50	.49	.47	.49	.48	.47	.47	.46
14	PRISMATIC INDUSTRIAL Clear Lamp 90° to 180°—18% 0° to 90°—73%	0.6	.33	.26	.21	.31	.25	.21	.24	.20
		0.8	.41	.35	.30	.39	.33	.29	.32	.29
		1.0	.45	.40	.35	.43	.39	.34	.37	.33
		1.25	.50	.44	.39	.47	.42	.38	.40	.37
		1.5	.52	.48	.43	.50	.45	.42	.43	.40
		2.0	.58	.54	.49	.56	.51	.47	.49	.46
		2.5	.63	.59	.54	.60	.56	.53	.54	.51
		3.0	.66	.62	.58	.63	.59	.56	.56	.54
		4.0	.71	.67	.63	.67	.63	.61	.60	.58
		5.0	.73	.69	.66	.69	.65	.63	.62	.60

TABLE 5—COEFFICIENTS OF UTILIZATION

Find *Room Index* from Table 4. Check Reflection Factors on Color Chart

DIRECT LIGHTING ENCLOSING AND SEMI-ENCLOSING UNITS

	COLOR REFLECTION FACTOR	CEILING	VERY LIGHT (70%)			FAIRLY LIGHT (50%)			FAIRLY DARK (30%)	
	WALLS		FAIRLY LIGHT (50%)	FAIRLY DARK (30%)	VERY DARK (10%)	FAIRLY LIGHT (50%)	FAIRLY DARK (30%)	VERY DARK (10%)	FAIRLY DARK (30%)	VERY DARK (10%)
	REFLECTOR TYPE	ROOM INDEX	COEFFICIENTS OF UTILIZATION							
15	DIFFUSING GLOBE Light Opal 90° to 180°—35% 0° to 90°—40%	0.6	.18	.13	.10	.16	.12	.10	.10	.09
		0.8	.22	.17	.14	.20	.16	.13	.14	.12
		1.0	.26	.21	.18	.23	.19	.16	.17	.14
		1.25	.29	.24	.21	.26	.22	.19	.19	.16
		1.5	.32	.27	.23	.29	.24	.21	.22	.19
		2.0	.37	.32	.28	.32	28	.25	.25	.22
		2.5	.40	.35	.31	.35	.31	.28	.28	.25
		3.0	.43	.38	.34	.38	.33	.30	.30	.27
		4.0	.47	.42	.38	.41	.37	.34	.33	.31
		5.0	.49	.45	.41	.43	.39	.36	.34	.33
16	ONE-PIECE OPAL Flattened Reflecting Top 90° to 180°—35% 0° to 90°—45%	0.6	.22	.17	.14	.20	.16	.13	.14	.12
		0.8	.27	.22	.19	.25	.21	.18	.19	.17
		1.0	.31	.26	.23	.28	.24	.21	.22	.19
		1.25	.35	.30	.26	.31	.27	.24	.25	.22
		1.5	.38	33	.29	.34	.30	.27	.27	.24
		2.0	.42	.38	.33	.38	.34	.31	.31	.28
		2.5	.46	.41	.37	.41	.37	.34	.34	.31
		3.0	.49	.45	.40	.43	.39	.36	.36	.33
		4.0	.53	.48	.44	.47	.43	.40	.38	.36
		5.0	.55	.51	.47	.49	.45	.42	.40	.38
17	PRISMATIC ENCLOSING 90° to 180°—27% 0° to 90°—59%	0.6	.28	.22	.18	.26	.21	.17	.19	.16
		0.8	.35	.29	.25	.33	.28	.24	.26	.23
		1.0	.38	.33	.29	.36	.32	.28	.30	.27
		1.25	.43	.37	.33	.40	.35	.31	.33	.30
		1.5	.46	.41	.36	.43	.38	.34	.35	.33
		2.0	.51	.46	.42	.47	.43	.40	.40	.38
		2.5	.55	.51	.46	.51	.47	.44	.44	.42
		3.0	.58	.54	.50	.54	.50	.47	.46	.44
		4.0	.62	.58	.55	.57	.54	.51	.50	.48
		5.0	.65	.61	.57	.60	.56	.53	.52	50
18	SEMI-ENCLOSING Metal Reflector 90° to 180°—20% 0° to 90°—56%	0.6	.22	.17	.13	.21	.16	.13	.15	.13
		0.8	.28	.22	.19	.26	.21	.18	.21	.18
		1.0	.31	.26	.23	.30	.25	.22	.24	.21
		1.25	.35	.30	.26	.32	.28	.25	.27	.24
		1.5	.38	.33	.28	.36	.31	.27	.30	.26
		2.0	.43	.38	.33	.40	.36	.32	.34	.30
		2.5	.46	.41	.37	.44	.39	.36	.37	.34
		3.0	.49	.44	.40	.46	.42	.38	.40	.37
		4.0	.54	.49	44	.50	.45	.42	.43	.40
		5.0	.56	.51	.47	.52	.47	.45	.44	.43
19	SEMI-ENCLOSING Compo Reflector 90° to 180°—13% 0° to 90°—60%	0.6	.24	.18	.14	.23	.18	14	.17	.14
		0.8	.30	.24	.21	.29	.24	.20	.23	.20
		1.0	.33	.28	.25	.32	.28	.24	.27	24
		1.25	.37	.32	.28	.35	.31	.27	.30	.27
		1.5	.39	.35	.31	.38	.34	.30	.32	.29
		2.0	.44	.40	.35	.42	.38	.34	.37	.34
		2.5	.48	.44	.39	.46	.42	.38	.41	.38
		3.0	.50	.46	.42	.48	.44	.41	.43	.40
		4.0	.55	.51	.47	.53	.49	.45	.46	.44
		5.0	.57	.53	.49	.54	.50	.47	.48	.46
20	TWO-PIECE GLASS Opal Reflector and Enameled Bowl 90° to 180°—12% 0° to 90°—53%	0.6	.22	.17	.14	.21	.17	.14	.16	.14
		0.8	.27	.23	.20	.26	.22	.19	.22	.19
		1.0	.30	.26	.23	.29	.26	.23	.25	.22
		1.25	.33	.29	.26	.32	.28	.26	.29	.25
		1.5	.36	.32	.29	.35	.31	.28	.31	.27
		2.0	.41	.37	.33	.39	.35	.32	.34	.31
		2.5	.44	.40	.36	.42	.38	.35	.37	.35
		3.0	.46	.42	.38	.43	.40	.37	.39	.37
		4.0	.49	.45	.42	.47	.43	.41	.42	.40
		5.0	.51	.48	.44	.48	.45	.43	.43	.41
21	ONE-PIECE GLASS Enameled Reflector and Bowl 90° to 180°—22% 0° to 90°—60%	0.6	.22	.17	.14	.21	.16	.14	.15	.14
		0.8	.27	.23	.20	.26	.22	.19	.20	.18
		1.0	.30	.26	.23	.29	.25	.22	.23	.21
		1.25	.34	.30	.26	.32	.28	.25	.26	.24
		1.5	.37	.33	.29	.34	.30	.27	.28	.26
		2.0	.41	.37	.33	.38	.34	.31	.32	.30
		2.5	.44	.40	.36	.41	.38	.35	.35	.33
		3.0	.47	.43	.39	.43	.40	.37	.37	.35
		4.0	.51	.47	.43	.47	.44	.41	.41	.39
		5.0	.53	.49	.45	.48	.45	.42	.42	.40

TABLE 5—COEFFICIENTS OF UTILIZATION

Find *Room Index* from Table 4. Check Reflection Factors on Color Chart

SEMI-INDIRECT AND INDIRECT LIGHTING UNITS

	Color Reflection Factor: Ceiling	Color Reflection Factor: Walls	Very Light (70%): Fairly Light (50%)	Very Light (70%): Fairly Dark (30%)	Very Light (70%): Very Dark (10%)	Fairly Light (50%): Fairly Light (50%)	Fairly Light (50%): Fairly Dark (30%)	Fairly Light (50%): Very Dark (10%)	Fairly Dark (30%): Fairly Dark (30%)	Fairly Dark (30%): Very Dark (10%)
	Reflector Type	Room Index	Coefficients of Utilization							
22	LIGHT OPAL	0.6	.18	.14	.11	.15	.12	.09	.09	.07
		0.8	.22	.18	15	.19	.15	.12	.12	.10
		1.0	.26	.22	.18	.22	.18	.15	.14	.12
		1.25	.30	.25	.22	.25	.21	.18	.16	.14
		1.5	.33	.28	.24	.27	.23	.20	.18	.16
	90° to 180°—60%	2.0	.38	.33	.29	.31	.27	.24	.21	.19
		2.5	41	.36	.32	.34	.30	.27	.24	.22
		3.0	.44	.39	.35	.36	.32	.29	.25	.23
		4.0	49	.44	40	.40	.36	.33	.28	.26
	0° to 90°—25%	5.0	.51	.46	.42	.42	.38	.35	.29	.28
23	DENSE OPAL (or Light Opal and Bowl-enameled Lamp)	0.6	.16	.13	.11	.12	.10	.08	.07	.06
		0.8	.20	.17	.15	.16	.13	.11	.09	.08
		1.0	.23	.20	.17	.18	.15	.13	.10	.09
		1.25	.27	.23	.20	.21	.18	.16	.12	.11
		1.5	.29	.26	.22	.23	.19	.17	.13	.12
	90° to 180°—70%	2.0	.33	.29	.26	.26	.22	.20	.15	.14
		2.5	.36	.32	.29	.28	.25	.23	.17	.16
		3.0	.39	.35	.32	.29	.27	.25	.18	.17
		4.0	.43	.39	.36	.32	.30	.28	.20	.19
	0° to 90°—10%	5.0	.45	.41	.38	.34	.32	.30	.22	.20
24	ENAMELED METAL REFLECTOR Opal Glass Bottom	0.6	.16	.13	.11	.12	.10	.08	.07	.06
		0.8	.19	.16	.14	.15	.13	.11	.08	.08
		1.0	.22	.19	.17	.17	.15	.13	.10	.09
		1.25	.25	.22	.19	.20	.17	.15	.11	.10
		1.5	.27	.24	.21	.21	.18	.16	.12	.11
	90° to 180°—69%	2.0	.31	.28	.25	.24	.21	.19	.14	.13
		2.5	.34	.31	.28	.25	.23	.22	.15	.15
		3.0	.36	.33	.31	.27	.25	.23	.16	.15
		4.0	.40	.37	.34	.29	.28	.26	.18	.17
	0° to 90°—6%	5.0	.41	.38	.37	.31	.29	.28	.19	.18
25	PRISMATIC ENCLOSED	0.6	.19	.15	.12	.16	.13	.10	.10	.09
		0.8	.24	.20	.17	.20	.17	.14	.14	.12
		1.0	.27	.23	.20	.23	.19	.17	.16	.14
		1.25	.31	.27	.23	.26	.22	.20	.18	.16
		1.5	.34	.29	.25	.28	.24	.22	.20	.18
	90° to 180°—57%	2.0	.38	.34	.30	.32	.28	.25	.22	.20
		2.5	.41	.37	.34	.34	.31	.28	.25	.23
		3.0	.44	.40	.36	.36	.33	.30	.26	.24
		4.0	.48	.44	.41	.40	.36	.34	.29	.27
	0° to 90°—26%	5.0	.50	.46	.43	.42	.38	.36	.30	.29
26	CLEAR TOP ENCLOSED Enameled Glass	0.6	.16	.12	.10	.13	.10	.08	.07	.06
		0.8	.20	.16	.13	.17	.13	.11	.10	.09
		1.0	.23	.19	.16	.19	.15	.13	.12	.10
		1.25	.26	.22	.19	.21	.18	.15	.14	.12
		1.5	.29	.25	.21	.24	.20	.17	.15	.13
	90° to 180°—54%	2.0	.32	.28	.25	.26	.23	.20	.18	.16
		2.5	.36	.31	.28	.29	.26	.23	.20	.18
		3.0	.38	.34	.31	.31	.28	.25	.22	.20
		4.0	.42	.38	.35	.34	.31	.29	.24	.22
	0° to 90°—21%	5.0	.44	.40	.37	.36	.33	.31	.25	.24
27	MIRRORED INDIRECT	0.6	.15	.12	.10	.11	.09	.07	.05	.04
		0.8	.18	.15	.13	.13	.11	.09	.07	.06
		1.0	.22	.19	.16	.15	.13	.11	.08	.07
		1.25	.25	.22	.19	.18	.15	.13	.09	.08
		1.5	.27	.24	.21	.20	.17	.15	.10	.09
	90° to 180°—80%	2.0	.30	.27	.25	.22	.19	.17	.11	.10
		2.5	.34	.31	.28	.24	.22	.20	.13	.12
		3.0	.36	.33	.30	.26	.24	.22	.14	.13
		4.0	.40	.37	.34	.28	.26	.24	.15	.14
	0° to 90°—0%	5.0	.42	.39	.37	.30	.28	.26	.17	.15
28	ENAMELED METAL INDIRECT	0.6	.14	.11	.10	.10	.08	.07	.04	.04
		0.8	.17	.14	.13	.13	.10	.09	.06	.05
		1.0	.20	.17	.15	.14	.12	.10	.07	.06
		1.25	.23	.20	.17	.17	.14	.13	.08	.07
		1.5	.25	.22	.19	.18	.15	.14	.09	.08
	90° to 180°—74%	2.0	.28	.25	.23	.21	.18	.16	.10	.10
		2.5	.31	.28	.26	.22	.20	.18	.12	.11
		3.0	.33	.30	.28	.24	.22	.20	.13	.12
		4.0	.37	.34	.32	.26	.24	.22	.14	.13
	0° to 90°—0%	5.0	.39	.36	.34	.28	.26	.24	.15	.14

TABLE No. 6—LUMEN OUTPUT OF MULTIPLE MAZDA LAMPS

Subject to Change Without Notice

Size of Lamp in Watts	110-115-120 Volt Standard Lighting Service: Mazda C	Mazda B	Daylight Mazda	220-230-240-250 Volt: Mazda C	Mazda B
	Approximate Lumen Output, Clear Lamps				
15	....	130	....	....	....
25	....	240†	....	....	200
40	....	400	....	....	....
50	450*	500†	....	....	420
60	....	620	....	....	....
75	900‡	....	600	....	....
100	1300	....	900	1000	....
150	2100	....	1400	....	....
200	3100	....	2100	2600	....
300	5000	....	3400	4300	....
500	9000	....	6300	8000	....
750	14000	....	....	13000	....
1000	20000	....	....	18000	....

* White Mazda.

† These two sizes in mill type construction give 200 and 450 lumens respectively.

‡ The 75-watt White Mazda lamp gives approximately 790 lumens.

TABLE 7—COMPUTED ILLUMINATION VALUES
Using Depreciation Factor of 1.3

Area in Square Ft. per Lamp	Size of Lamp		COEFFICIENT OF UTILIZATION															
			.14	.16	.18	.20	.22	.25	.28	.32	.36	.40	.45	.50	.55	.60	.65	.70
	Watts	Lumens	FOOT-CANDLES															
60	100	1300	2.3	2.7	3.0	3.3	3.7	4.2	4.7	5.3	6.0	6.7	7.5	8.3	9.2	10.0	10.8	11.7
	150	2100	3.8	4.3	4.8	5.4	5.9	6.7	7.5	8.6	9.7	10.8	12.1	13.5	14.8	16.2	17.5	18.8
	200	3100	5.6	6.4	7.2	7.9	8.7	9.9	11.1	12.7	14.3	15.9	17.9	19.9	21.8	23.8	25.8	27.8
	300	5000	9.0	10.2	11.5	12.8	14.1	16.0	17.9	20.5	23.0	25.6	28.8	32.0	35.2	38.4	41.6	44.7
70	100	1300	2.0	2.3	2.6	2.9	3.1	3.6	4.0	4.6	5.1	5.7	6.4	7.1	7.9	8.6	9.3	10.0
	150	2100	3.2	3.7	4.2	4.6	5.1	5.8	6.5	7.4	8.3	9.2	10.4	11.5	12.7	13.8	15.0	16.2
	200	3100	4.8	5.4	6.1	6.8	7.5	8.5	9.5	10.9	12.3	13.6	15.3	17.0	18.7	20.4	22.4	23.8
	300	5000	7.7	8.8	9.9	11.0	12.1	13.7	15.4	17.6	19.7	22.0	24.7	27.4	30.2	33.0	36.7	38.5
80	100	1300	1.8	2.0	2.2	2.5	2.8	3.1	3.5	4.0	4.5	5.0	5.6	6.2	6.9	7.5	8.1	8.7
	150	2100	2.8	3.2	3.6	4.0	4.4	5.0	5.7	6.5	7.3	8.1	9.1	10.1	11.1	12.1	13.1	14.1
	200	3100	4.2	4.8	5.4	6.0	6.6	7.4	8.3	9.5	10.7	11.9	13.4	14.9	16.4	17.9	19.4	10.9
	300	5000	6.7	7.7	8.6	9.6	10.5	12.0	13.4	15.3	17.3	19.2	21.6	24.0	26.4	28.8	31.2	33.6
90	100	1300	1.6	1.8	2.0	2.2	2.4	2.8	3.1	3.6	4.0	4.5	5.0	5.6	6.1	6.7	7.2	7.8
	150	2100	2.5	2.9	3.2	3.6	3.9	4.5	5.0	5.7	6.5	7.2	8.1	9.0	9.9	10.8	11.7	12.6
	200	3100	3.7	4.2	4.8	5.3	5.8	6.6	7.4	8.5	9.5	10.6	11.9	13.2	14.5	15.9	17.2	18.5
	300	5000	6.0	6.8	7.7	8.6	9.4	10.7	12.0	13.6	15.4	17.0	19.2	21.3	23.4	25.6	27.7	29.9
100	100	1300	1.4	1.6	1.6	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.5	6.0	6.5	7.0
	150	2100	2.3	2.6	2.9	3.2	3.6	4.0	4.5	5.2	5.8	6.5	7.3	8.1	8.9	9.7	10.5	11.3
	200	3100	3.3	3.8	4.3	4.8	5.2	5.9	6.7	7.6	8.6	9.5	10.7	11.9	13.1	14.3	15.5	16.7
	300	5000	5.4	6.2	7.0	7.7	8.5	9.7	10.8	12.4	13.9	15.5	17.4	19.3	21.3	23.2	25.2	27.1
110	100	1300	1.3	1.5	1.6	1.8	2.0	2.3	2.5	2.7	3.3	3.6	4.1	4.5	5.0	5.5	5.9	6.4
	150	2100	2.1	2.4	2.6	2.9	3.2	3.7	4.1	4.7	5.3	5.9	6.6	7.3	8.1	8.8	9.5	10.2
	200	3100	3.0	3.5	3.9	4.3	4.8	5.4	6.1	6.8	7.8	8.7	9.8	10.8	11.9	13.0	14.0	15.2
	300	5000	4.9	5.6	6.3	7.0	7.7	8.7	9.8	11.2	12.6	14.0	15.7	17.5	19.3	21.0	22.8	24.5
120	100	1300	1.2	1.3	1.5	1.7	1.8	2.1	2.3	2.7	3.0	3.3	3.8	4.2	4.6	5.0	5.4	5.8
	150	2100	1.9	2.2	2.4	2.7	3.0	3.4	3.8	4.3	4.8	5.4	6.1	6.7	7.4	8.1	8.8	9.4
	200	3100	2.8	3.2	3.6	4.0	4.4	5.0	5.6	6.3	7.1	7.9	8.9	9.9	11.0	12.0	13.0	14.0
	300	5000	4.5	5.1	5.8	6.4	7.0	8.0	9.0	10.2	11.5	12.8	14.4	16.0	17.6	19.2	20.8	22.4
130	100	1300	1.1	1.2	1.4	1.5	1.7	1.9	2.2	2.5	2.8	3.1	3.5	3.8	4.2	4.6	5.0	5.4
	150	2100	1.7	2.0	2.2	2.5	2.7	3.1	3.5	4.0	4.5	5.0	5.6	6.2	6.8	7.5	8.1	8.7
	200	3100	2.6	2.9	3.3	3.7	4.0	4.5	5.1	5.9	6.6	7.4	8.3	9.2	10.1	11.0	11.9	12.8
	300	5000	4.1	4.7	5.3	5.9	6.5	7.4	8.3	9.4	10.3	11.8	13.3	14.7	16.2	17.7	19.2	20.6
140	100	1300	1.0	1.1	1.3	1.4	1.6	1.8	2.0	2.3	2.6	2.9	3.2	3.6	3.9	4.3	4.6	5.0
	150	2100	1.6	1.8	2.1	2.3	2.5	2.9	3.2	3.7	4.2	4.6	5.2	5.8	6.3	6.9	7.5	8.1
	200	3100	2.4	2.7	3.1	3.4	3.8	4.3	4.8	5.5	6.1	6.8	7.7	8.5	9.4	10.2	11.1	11.9
	300	5000	3.8	4.4	4.9	5.5	6.0	6.8	7.7	8.8	9.9	11.0	12.3	13.7	15.0	16.4	17.8	19.2
150	100	1300	0.9	1.1	1.2	1.3	1.5	1.7	1.9	2.1	2.4	2.7	3.0	3.3	3.7	4.0	4.3	4.7
	150	2100	1.5	1.7	1.9	2.2	2.4	2.7	3.0	3.4	3.9	4.3	4.4	5.4	5.9	6.5	7.0	7.5
	200	3100	2.2	2.5	2.9	3.2	3.5	4.0	4.5	5.1	5.7	6.4	7.2	7.9	8.7	9.5	10.3	11.1
	300	5000	3.6	4.1	4.6	5.1	5.6	6.4	7.2	8.2	9.2	10.2	11.5	12.8	14.1	15.4	16.6	17.9
160	150	2100	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.6	6.1	6.6	7.1
	200	3100	2.1	2.4	2.7	3.0	3.3	3.7	4.2	4.8	5.4	5.9	6.7	7.4	8.2	8.9	9.7	10.5
	300	5000	3.4	3.8	4.3	4.8	5.3	6.0	6.7	7.7	8.6	9.6	10.8	12.0	13.2	14.4	15.6	16.8
	500	9000	6.0	6.9	7.8	8.1	9.5	10.8	12.0	13.8	15.5	17.3	19.4	21.3	23.7	25.9	28.0	30.2
170	150	2100	1.3	1.5	1.7	1.9	2.1	2.4	2.7	3.0	3.4	3.8	4.3	4.8	5.2	5.7	6.2	6.7
	200	3100	2.0	2.2	2.5	2.8	3.1	3.5	3.9	4.5	5.1	5.6	6.3	7.0	7.7	8.4	9.1	9.8
	300	5000	3.2	3.6	4.1	4.5	5.0	5.5	6.3	7.2	8.1	9.0	10.2	11.3	12.4	13.6	14.7	15.8
	500	9000	5.7	6.5	7.3	8.1	9.0	10.2	11.4	13.0	14.6	16.3	18.3	20.4	22.4	24.4	26.5	28.5
180	150	2100	1.3	1.4	1.6	1.8	2.0	2.2	2.5	2.9	3.2	3.6	4.0	4.5	4.9	5.4	5.8	6.3
	200	3100	1.8	2.1	2.4	2.6	2.9	3.1	3.6	4.2	4.8	5.3	5.9	6.6	7.3	7.9	8.6	9.3
	300	5000	3.0	3.4	3.8	4.3	4.7	5.3	6.0	6.8	7.7	8.5	9.6	10.6	11.7	12.8	13.8	14.9
	500	9000	5.4	6.2	6.9	7.7	8.5	9.6	10.8	12.3	13.9	15.4	17.3	19.2	21.2	23.1	25.0	26.9
190	150	2100	1.2	1.4	1.5	1.7	1.9	2.1	2.4	2.7	3.1	3.4	3.8	4.2	4.7	5.1	5.5	5.9
	200	3100	1.8	2.0	2.3	2.5	2.8	3.1	3.5	4.0	4.5	5.0	5.7	6.3	6.9	7.5	8.2	8.8
	300	5000	2.8	3.2	3.6	4.0	4.4	5.0	5.7	6.5	7.8	8.1	9.1	10.1	11.1	12.1	13.1	14.1
	500	9000	5.1	5.8	6.5	7.3	8.0	9.1	10.2	11.6	13.2	14.5	16.4	18.2	20.0	21.8	23.6	25.4
200	150	2100	1.1	1.3	1.5	1.6	1.8	2.0	2.3	2.6	2.9	3.2	3.6	4.0	4.4	4.8	5.3	5.7
	200	3100	1.7	1.9	2.1	2.4	2.6	3.0	3.3	3.8	4.3	4.8	5.3	6.0	6.5	7.1	7.7	8.3
	300	5000	2.7	3.1	3.5	3.8	4.2	4.8	5.4	6.1	6.9	7.7	8.6	9.6	10.6	11.5	12.5	13.4
	500	9000	4.8	5.5	6.2	6.9	7.6	8.6	9.7	11.1	12.5	13.7	15.6	17.3	19.0	20.8	22.5	24.2
220	150	2100	1.0	1.2	1.3	1.5	1.6	1.8	2.1	2.3	2.7	2.9	3.3	3.6	4.1	4.4	4.8	5.1
	200	3100	1.5	1.7	2.0	2.2	2.4	2.7	3.2	3.4	3.9	4.4	4.9	5.4	5.9	6.5	7.0	7.6
	300	5000	2.4	2.8	3.1	3.5	3.8	4.4	4.9	5.6	6.3	7.0	7.9	8.7	9.6	10.5	11.4	12.3
	500	9000	4.4	5.0	5.6	6.3	6.9	7.8	8.8	10.0	11.3	12.6	14.1	15.7	17.3	18.9	20.4	22.0
240	200	3100	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.5	3.9	4.5	5.0	5.5	6.0	6.5	7.0
	300	5000	2.2	2.6	2.9	3.2	3.5	4.0	4.5	5.1	5.8	6.4	7.2	8.0	9.8	9.6	10.4	11.2
	500	9000	4.0	4.6	5.2	5.8	6.4	7.2	8.1	9.2	10.4	11.6	13.0	14.5	15.9	17.3	18.8	20.2
	750	14000	6.3	7.2	8.1	9.0	9.9	11.3	12.6	14.4	16.2	18.0	20.3	22.5	24.7	27.0	29.3	31.5

TABLE 7—COMPUTED ILLUMINATION VALUES
Using Depreciation Factor of 1.3

Area in Square Ft. per Lamp	Size of Lamp		COEFFICIENT OF UTILIZATION															
			.14	.16	.18	.20	.22	.25	.28	.32	.36	.40	.45	.50	.55	.60	.65	.70
	Watts	Lumens	FOOT-CANDLES															
260	200	3100	1.3	1.5	1.6	1.8	2.0	2.3	2.6	2.9	3.3	3.7	4.1	4.6	5.0	5.5	6.0	6.4
	300	5000	2.1	2.4	2.7	3.0	3.3	3.7	4.1	4.7	5.3	5.9	6.7	7.4	8.1	8.9	9.6	10.3
	500	9000	3.7	4.3	4.8	5.3	5.9	6.6	7.5	8.5	9.6	10.6	12.0	13.3	14.6	16.0	17.3	18.6
	750	14000	5.8	6.6	7.5	8.3	9.1	10.4	11.6	13.2	14.9	16.6	18.6	20.7	22.8	24.8	26.9	29.0
280	200	3100	1.2	1.4	1.5	1.7	1.9	2.1	2.4	2.7	3.1	3.4	3.8	4.3	4.7	5.1	5.5	6.0
	300	5000	1.9	2.2	2.5	2.7	3.0	3.4	3.8	4.4	4.9	5.5	6.2	6.9	7.5	8.2	8.9	9.6
	500	9000	3.5	4.0	4.4	4.9	5.4	6.2	6.9	7.9	8.9	9.9	11.1	12.3	13.6	14.8	16.0	17.3
	750	14000	5.4	6.2	6.9	7.7	8.5	9.6	10.8	12.3	13.8	15.4	17.3	19.2	21.2	23.1	25.0	26.9
320	200	3100	1.0	1.2	1.3	1.5	1.6	1.9	2.1	2.4	2.7	3.0	3.4	3.7	4.1	4.5	4.9	5.2
	300	5000	1.7	1.9	2.2	2.4	2.6	3.0	3.4	3.8	4.3	4.8	5.4	6.0	6.6	7.2	7.8	8.4
	500	9000	3.0	3.5	3.9	4.3	4.8	5.4	6.1	6.9	7.8	8.6	9.7	10.8	11.9	13.0	14.0	15.1
	750	14000	4.7	5.4	6.0	6.7	7.4	8.4	9.4	10.7	12.1	13.4	15.1	16.8	18.5	20.2	21.8	23.5
360	200	3100	0.9	1.1	1.2	1.3	1.5	1.7	1.9	2.1	2.4	2.7	3.0	3.3	3.6	4.0	4.3	4.6
	300	5000	1.5	1.7	1.9	2.1	2.4	2.7	3.0	3.4	3.9	4.3	4.8	5.4	5.9	6.4	7.0	7.5
	500	9000	2.7	3.1	3.5	3.8	4.2	4.8	5.4	6.1	6.9	7.7	8.6	9.6	10.6	11.5	12.5	13.5
	750	14000	4.2	4.8	5.4	6.0	6.6	7.5	8.4	9.6	10.8	12.0	13.5	15.0	16.5	18.0	19.5	21.0
400	200	3100	0.8	0.9	1.1	1.2	1.3	1.5	1.7	1.9	2.1	2.4	2.7	3.0	3.3	3.6	3.9	4.2
	300	5000	1.3	1.5	1.7	1.9	2.1	2.4	2.7	3.1	3.5	3.9	4.3	4.8	5.3	5.8	6.3	6.7
	500	9000	2.4	2.8	3.1	3.5	3.8	4.3	4.8	5.5	6.2	6.9	7.8	8.6	9.5	10.4	11.2	12.1
	750	14000	3.8	4.3	4.9	5.4	5.9	6.8	7.6	8.6	9.7	10.8	12.2	13.5	14.9	16.2	17.6	18.9
450	200	3100	0.7	0.8	1.0	1.1	1.2	1.3	1.5	1.7	1.9	2.1	2.4	2.6	2.9	3.2	3.5	3.7
	300	5000	1.2	1.4	1.5	1.7	1.9	2.1	2.4	2.7	3.1	3.4	3.9	4.3	4.7	5.1	5.6	6.0
	500	9000	2.2	2.5	2.8	3.1	3.4	3.9	4.3	4.9	5.5	6.2	6.9	7.7	8.5	9.2	10.0	10.8
	750	14000	3.4	3.8	4.3	4.8	5.3	6.0	6.7	7.7	8.6	9.6	10.8	12.0	13.2	14.4	15.6	16.8
500	300	5000	1.1	1.2	1.4	1.5	1.7	1.9	2.2	2.5	2.8	3.1	3.5	3.9	4.2	4.6	5.0	5.4
	500	9000	1.9	2.2	2.4	2.7	3.0	3.5	3.7	4.4	5.0	5.5	6.2	6.9	7.6	8.3	9.0	9.7
	750	14000	3.0	3.4	3.9	4.3	4.7	5.4	6.0	6.9	7.7	8.6	9.7	10.7	11.8	12.9	14.0	15.0
	1000	20000	4.3	4.9	5.5	6.2	6.8	7.7	8.6	9.8	11.1	12.3	13.8	15.4	16.9	18.4	20.0	21.5
600	300	5000	0.9	1.0	1.1	1.3	1.4	1.6	1.8	2.0	2.3	2.6	2.9	3.2	3.5	3.8	4.2	4.5
	500	9000	1.6	1.8	2.1	2.3	2.5	2.9	3.2	3.7	4.1	4.6	5.2	5.8	6.3	6.9	7.5	8.0
	750	14000	2.5	2.9	3.2	3.6	4.0	4.5	5.0	5.8	6.5	7.2	8.1	9.0	9.9	10.8	11.7	12.6
	1000	20000	3.6	4.1	4.6	5.1	5.6	6.4	7.2	8.2	9.2	10.3	11.5	12.8	14.1	15.4	16.7	18.0
700	300	5000	0.8	0.9	1.0	1.1	1.2	1.4	1.5	1.8	2.0	2.2	2.5	2.8	3.0	3.3	3.6	3.9
	500	9000	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.2	3.6	4.0	4.5	5.0	5.5	5.9	6.4	6.9
	750	14000	2.2	2.5	2.8	3.1	3.4	3.9	4.3	4.9	5.5	6.2	6.9	7.7	8.5	9.2	10.0	10.8
	1000	20000	3.1	3.5	4.0	4.4	4.8	5.5	6.2	7.0	7.9	8.8	9.9	11.0	12.1	13.2	14.3	15.4
800	300	5000	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.5	1.7	1.9	2.2	2.4	2.6	2.9	3.1	3.4
	500	9000	1.2	1.4	1.6	1.7	1.9	2.2	2.4	2.8	3.1	3.5	3.9	4.3	4.8	5.2	5.6	6.1
	750	14000	1.7	2.0	2.2	2.4	2.7	3.1	3.4	3.9	4.4	4.9	5.9	6.1	6.7	7.3	7.9	8.6
	1000	20000	2.7	3.1	3.5	3.8	4.2	4.8	5.4	6.2	6.9	7.7	8.7	9.6	10.6	11.5	12.5	13.5
900	300	5000	0.6	0.7	0.8	0.9	0.9	1.1	1.2	1.4	1.5	1.7	1.9	2.1	2.3	2.6	2.8	3.0
	500	9000	1.1	1.2	1.4	1.5	1.7	1.9	2.2	2.5	2.8	3.1	3.5	3.8	4.2	4.6	5.0	5.4
	750	14000	1.7	1.9	2.2	2.4	2.6	3.0	3.3	3.8	4.3	4.8	5.4	6.0	6.6	7.2	7.8	8.4
	1000	20000	2.4	2.7	3.1	3.4	3.8	4.3	4.8	5.5	6.2	6.8	7.7	8.6	9.4	10.3	11.1	12.0
1000	300	5000	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.4	1.5	1.7	1.9	2.1	2.3	2.5	2.7
	500	9000	1.0	1.1	1.2	1.4	1.5	1.7	1.9	2.2	2.5	2.8	3.1	3.5	3.8	4.1	4.5	4.8
	750	14000	1.5	1.7	1.9	2.2	2.4	2.7	3.0	3.4	3.9	4.2	4.8	5.4	5.9	6.5	7.0	7.5
	1000	20000	2.2	2.5	2.8	3.1	3.4	3.8	4.3	4.9	5.5	6.2	6.9	7.7	8.5	9.2	10.0	10.8
1200	300	5000	0.4	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.1	1.3	1.4	1.6	1.8	1.9	2.1	2.2
	500	9000	0.8	0.9	1.0	1.2	1.3	1.4	1.6	1.8	2.1	2.3	2.6	2.9	3.2	3.5	3.7	4.0
	750	14000	1.3	1.4	1.6	1.8	2.0	2.2	2.5	2.9	3.2	3.6	4.0	4.5	5.0	5.4	5.9	6.3
	1000	20000	1.8	2.1	2.3	2.6	2.8	3.2	3.6	4.1	4.6	5.1	5.8	6.4	7.1	7.7	8.3	9.0
1400	300	5000	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.4	1.5	1.6	1.8	1.9
	500	9000	0.7	0.8	0.9	1.0	1.1	1.2	1.4	1.6	1.8	2.0	2.2	2.5	2.7	3.0	3.2	3.5
	750	14000	1.1	1.2	1.4	1.5	1.7	1.9	2.2	2.5	2.8	3.1	3.5	3.8	4.2	4.6	5.0	5.4
	1000	20000	1.5	1.8	2.0	2.2	2.4	2.7	3.1	3.5	4.0	4.4	4.9	5.5	6.0	6.6	7.1	7.7
1600	300	5000	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.6	1.7
	500	9000	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.4	1.6	1.7	1.9	2.2	2.4	2.6	2.8	3.0
	750	14000	0.9	1.1	1.2	1.3	1.5	1.7	1.9	2.2	2.4	2.7	3.0	3.4	3.7	4.0	4.4	4.7
	1000	20000	1.3	1.5	1.7	1.9	2.1	2.4	2.7	3.1	3.5	3.8	4.3	4.8	5.3	5.8	6.2	6.7
2000	300	5000	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.2	1.3
	500	9000	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.4	1.6	1.7	1.9	2.1	2.2	2.4
	750	14000	0.8	0.9	1.0	1.1	1.2	1.3	1.5	1.7	1.9	2.2	2.4	2.7	3.0	3.2	3.5	3.8
	1000	20000	1.1	1.2	1.4	1.5	1.7	1.9	2.2	2.5	2.8	3.1	3.5	3.8	4.2	4.6	5.0	5.4
2500	300	5000	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.7	0.8	0.8	0.9	1.0	1.1
	500	9000	0.4	0.4	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.4	1.5	1.7	1.8	1.9
	750	14000	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.4	1.5	1.7	1.9	2.1	2.4	2.6	2.8	3.0
	1000	20000	0.9	1.0	1.1	1.2	1.4	1.5	1.7	2.0	2.2	2.5	2.8	3.1	3.4	3.7	4.0	4.3

(*Continued from page* 321)

Note: Table 2 is intended to show representative equipment of different constructions. Hence some which have a very limited application such as No. 7, flat cone with clear lamps, are included merely for purposes of comparison while at the same time many equipments of wide application, but generally similar in performance to these listed, have been omitted on account of space limitations.

It is important that good reflecting equipment be installed. The luminaires shown in these charts illustrate certain types. For example, No. 15 and No. 16 show units of a general type of which there are a great variety made by various manufacturers. Of two or more units of the same type the choice should be governed by considerations of brightness, diffusion, absorption, appearance, and cost, and not by cost alone. Of two samples of glass enclosing globes, outwardly identical, one may absorb 30 per cent of the light and the other only 15 per cent for the same degree of diffusion. Products of reliable manufacturers should be chosen if comparative photometric data are not available.

SECTION 2

Railway Shop and Roundhouse Lighting

200. Three Levels of Lighting Practice

Artificial illumination of today can be considered existing in three stages as follows:

Lighting for safety
Ordinary practice
Productive lighting

A number of the leading industrial states of the Union have recognized the importance of artificial illumination and have formulated lighting codes for the express purpose of regulating lighting conditions in factories, mills and other work places with a view to insuring safe working conditions.

The rules and regulations contained in these various state codes, however, approach the subject from the safety standpoint only, and specify the minimum amount of light which is considered necessary to the safety of the worker. The intensities specified in the state codes do not provide for those higher intensities of artificial light which a brief study of the problem and ordinary economics prove should be used.

Good lighting practice specifies the use of a higher intensity than that recommended for safety if the night-time efficiency of workers is to be prevented from falling far below the daytime level. By good lighting practice is meant intensities of the order of those recommended in the various tables of intensities specified for various classes of work in recent lighting literature. Such intensities range approximately from 5 to 15 foot candles.

It is common knowledge that the daytime efficiency of workers falls off quite materially as darkness falls. In order to prevent this reduction in personal efficiency much higher intensities than those ordinarily recommended are necessary. Thus a new term, productive lighting, has come into use which indicates the use of intensities high enough to secure the full efficiency of the workers. Tests conducted in various industrial establishments over the past few years proved conclusively that such lighting not only brings results but is also economical and well worth the effort. A summary of such production tests is shown in Table I.

TABLE I

Kind of Work	EQUIPMENT Old	EQUIPMENT New	INTENSITY Old	INTENSITY New	Per Cent Increase in Production
Stamping and pressing	Bare local lamps	RLM reflectors, B.E. Mazda C lamps	0.7	13	12.2
Semi-automatic buffing	300-w. clear Mazda lamps, bowl reflectors	500w. B.E. Mazda C lamps, RLM reflectors	3.8	11.4	8.5
Iron pulley finishing	Bare local lamps	200-w. Mazda C lamps, reflecto cap diffusers	0.2	4.8	35.0
Soft metal bearings	100-w. Mazda B lamps, bowl reflectors	200-w. Mazda C lamps, deep bowl steel reflectors	4.6	12.7	15.0
Heavy steel machining	100-w. Mazda C lamps, shallow dome, eye shield units	300-w. lamps, same type of units	3.0	11.7	10.0
Carburetor assembling	Small lamps, bare, conical shades	300-w. eye-shield units	2.1	12.5	12.0
Spinning (Textile Mill)	Mazda B lamps, conical reflectors	B.E. Mazda C lamps, RLM reflectors	1.5	9.0	17.0

Productive lighting, however, should not be applied indiscriminately to all classes of work as obviously where the work is more or less automatic or where it is intermittent in character and consequently labor expense relatively smaller it cannot be speeded up appreciably by the addition of more light. Where labor expense is a large proportion of the total cost of the work and is of such character to require considerable visual effort the use of productive lighting can generally be justified.

Lighting Equipment

201. Lamps

The types of lamps used in shop lighting consist of but a few well chosen types. Thus for general lighting of work spaces the gas-filled Mazda C lamp in wattages ranging from 75 to 500 will meet all ordinary requirements. Wherever conditions permit the higher wattage lamps should be used since the light output or efficiency increases rapidly with size of lamp. Thus one 500 watt Mazda C lamp emits the same amount of light as do seven 100 watt Mazda C lamps.

On account of the high brilliancy of the light from the concentrated filament of the Mazda C lamp its use is apt to prove glaring unless precautions are taken to shield the eye from the direct rays of the lamp. This objectionable effect can be overcome by the use of bowl enameled lamps which from the point of view of satisfactory illumination should be employed when lamps are used in open type of reflectors with mounting heights of less than 20 to 30 feet depending upon the size of the lamp. The use of the deep bowl reflector will also aid considerably in reducing the glare effect.

It is not expected that the general lighting system will effectively provide light to all working points. Portable lamps on extension cords are therefore required in some places. The lamps used for this service can be either of the mill type which is specially designed for rough usage, or the 30-volt lamp operated from special low voltage circuits. The practice of running low voltage lines to supply extension lamps is becoming more general since such a lamp has the advantage of ruggedness in addition to high light efficiency.

202. Reflectors

The reflectors required for general shop lighting can be confined to a few well chosen types as follows:

RLM standard dome reflector.
Elliptical angle reflector.
Bowl reflector.
Half-shade reflector for portable lamps.

The RLM standard dome reflector, which derives its name from the fact that it is a standard design evolved by the reflector and lamp manufacturers of the country, will meet fully 75 per cent of the lighting requirements of railroad shops. This reflector was specially designed to accommodate the Mazda C lamp, and for this reason is provided with a skirt around the rim of the reflector such as to cut off all direct rays from these lamps to a point 17½ degrees below the horizontal. Fig. 1-C shows the RLM dome reflector. Its principal service is in connection with the general lighting installation for which its wide distribution is well adapted.

Illumination on vertical surfaces is just as important as that on horizontal surfaces, due to the peculiar class of work carried on in railroad shops. Special efforts, therefore, must be made to provide lighting on such surfaces, and the elliptical angle reflector shown in Fig. 1-E is well suited to provide the proper distribution of light on such working points as the sides of locomotives in the erecting shop and to prevent confusing shadows along the sides of the mold in foundries.

One of the principal objections to use of portable lamps lies in the fact that if improperly used they are likely to prove very glaring. Half shade reflectors similar to the ones illustrated in Figs. 1-A and 1-B are recommended for this service.

For those shops in which the ceiling height is quite low, i. e., nine feet or less, the principal consideration, aside from that of good illumination, is to reduce glare as much as possible due to the low hanging height of lighting units. A type of reflector having a much sharper cut-off than the RLM dome is therefore highly desirable. For these conditions the deep bowl type of reflector, illustrated in Fig. 1-D, which has an angle of cut off of about 30 deg., is recommended.

For the modern high type erecting shop with a height of 75 feet or more to accommodate traveling cranes on two levels, the lighting problem is more difficult to solve.

It is obviously necessary to hang the lighting units high enough to clear the crane, and a concentrating type of unit which may be eiter of a special focusing type industrial unit equipped with

mirrored glass reflectors or the special prismatic glass industrial units are recommended for such service.

203. Types of Shop Buildings

The types of shop buildings commonly encountered in railway service can be classified according to two principal groups.

Group A consists of those buildings having high ceilings which are relatively long in comparison to their width, being equipped with either one or two crane levels. Examples of such structures are, erecting shops, car repair shops and foundries.

Group B consists of those buildings of ordinary ceiling height ranging from 12 to 20 feet, of which machine shops, flue shops, forge shops, etc., are examples.

These two types of structures are shown in Fig. 2, and it is obvious that both types require distinctly different lighting installations.

In the high ceiling structure it is obviously an advantage to use the high wattage lamps and so secure the benefit of their higher operating efficiency. Lower wattage lamps, however, must be used in the case of the Group B structures if glare is to be avoided, or if high wattage lamps, i. e., 300 or 500 watt lamps are used, special precautions must be taken to guard against glare.

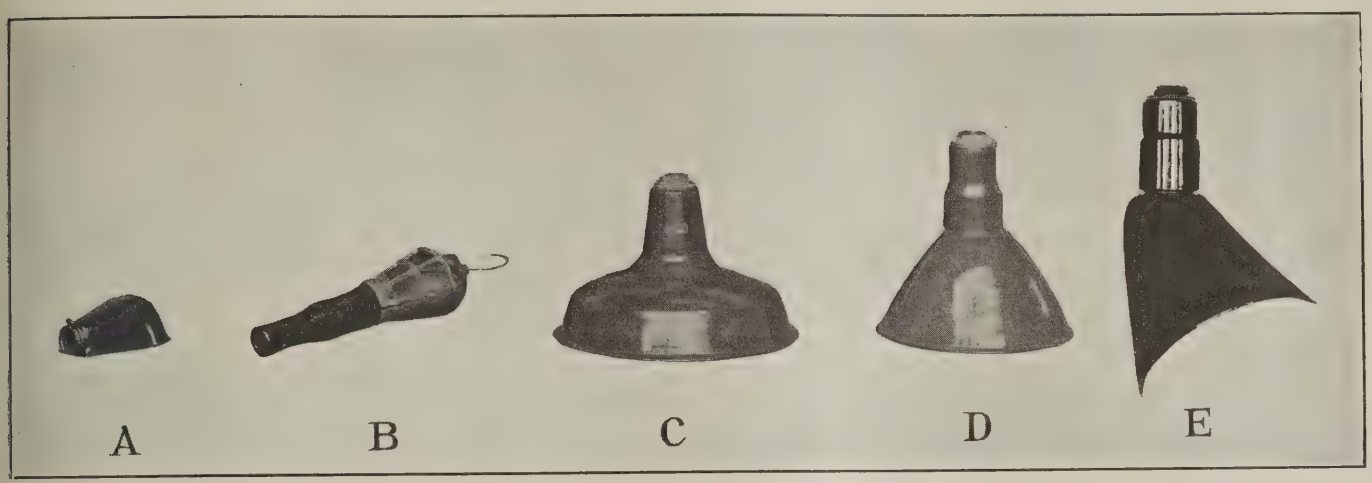


Fig. 1—Common Types of Reflectors Used in Railroad Service—A—Half Shade Reflector; B—Portable Lamp Reflector and Guard C—R. L. M. Standard Dome Reflector; D—Deep Bowl Reflector; E—Elliptical Angle Reflector

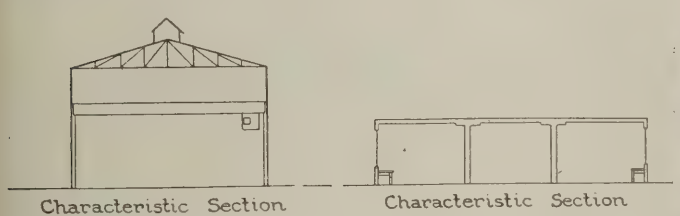


Fig. 2—Sketch Showing Typical Sections of Group "A" and Group "B" Shops

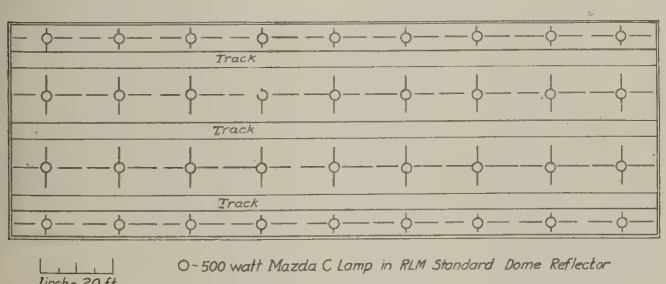


Fig. 3—Plan of Erecting Shop with Low Ceiling

Recommended Lighting Practice for Various Kinds of Shops

204. Erecting Shops

Erecting shops can in general be classified according to their size. There is a small group of shops in which the ceiling height ranges from 16 to 20 feet; a second group, in which the ceiling height ranges from 20 to 50 feet, and which is the average condition; and a third group of newer construction in which the ceiling height ranges from 50 to fully 100 feet.

The low ceiling shop of the first class can best be lighted by a localized general system of lighting using either 200 or 300 watt Mazda C lamps in RLM dome reflectors arranged in rows with one row of lighting units over the center of each aisle. The layout for such a system is shown in Fig. 3. It is desirable to hang the units fairly high in order to provide light on any point from a number of units, thus breaking up shadows and securing good vertical illumination. It is further desirable to paint the interior of the structure, such as the walls and columns, a flat white in order to further improve light diffusion and assist in lighting the sides of the locomotives. A night view of the interior of such a shop is shown in Fig. 4.

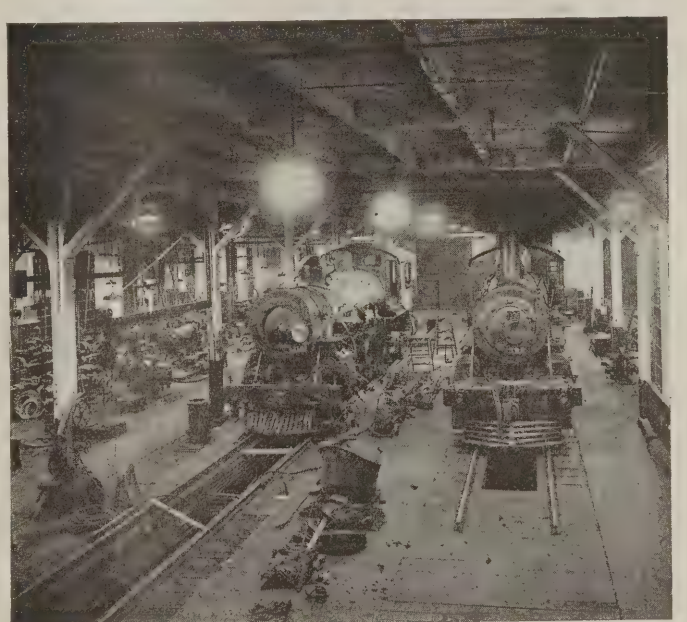


Fig. 4—Night View of Erecting Shop Lighted by 500-Watt Mazda C Lamps in R. L. M. Dome Reflectors Hung 17½ Ft. High and Spaced on 15 Ft. Centers. This System Is Particularly Applicable to Shops Having a Low Ceiling Height. Intensity 12 Foot-Candles

Erecting shops of the second class in which the ceiling height is ordinarily 50 or 60 feet require special attention in the way of providing good intensity on the vertical sides of the locomotive. Such shops are laid out in one of two ways; with longitudinal tracks or transverse tracks. Whichever arrangement is used the lighting installation is practically the same in each case; that is, general lighting is provided by a system of high wattage Mazda

C lamps in RLM standard dome reflectors arranged in rows down the length of the shop and a supplementary system consisting of high wattage Mazda C lamps in elliptical angle reflectors mounted on the side walls of the structure to provide the necessary vertical illumination is also used. The elliptical angle units in the case of the erecting shop possessing but three or four tracks the entire length of the shop should be spaced on even centers in order to provide a good distribution of light over the working area. Where the tracks extend across the shop, it is customary to place two

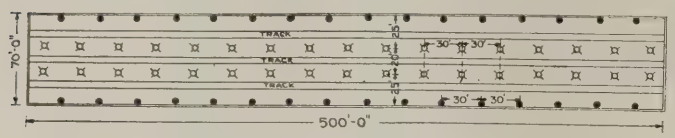


Fig. 5—Plan of Erecting Shop With Medium Ceiling

elliptical angle units, one on each side of the shop, for each aisle between tracks. For both cases the spacing will be but slightly different. A plan view of an erecting shop of medium height is shown in Fig. 5, and a night view of the same shop showing the good illumination effects obtainable with such a system is shown in Fig. 6.

205. Machine, Wheel, Forge, Flueshop, etc.

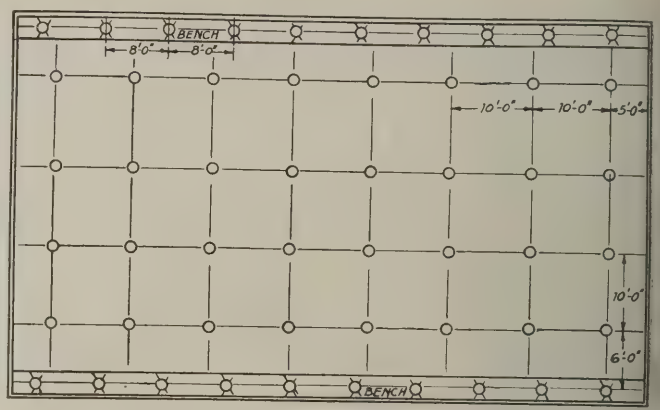
The shops grouped under this heading are contained in rooms approximating those of the average factory. The lighting of

Fig. 6—Night View of Erecting Shop Lighted by Two Rows of 500-Watt Mazda C Lamps in R. L. M. Dome Reflectors Spaced on 20 Ft. by 30 Ft. Centers Down the Center of the Shop and 500-Watt Mazda C Lamps in Elliptical Angle Reflectors Spaced 30 Ft. Apart and Hung on Each Side Wall. Both Types of Units Are Hung Approximately 30 Ft. High. Intensity Provided Is Seven Foot-Candles. Good Light on Vertical Surfaces

them, therefore, becomes a problem similar to that of the ordinary industrial plant.

The shop in general should be lighted by a straight general system of lighting employing from 150 to 500 watt Mazda C lamps in RLM standard dome reflectors spaced on even centers, such as, 12 x 12, 15 x 15, etc. The hanging height in any case should range from between 10 and 15 feet. The greater height is preferable if it can be obtained.

Of the shops in this class, the machine shop presents the most difficult problem. Common practice in past years has involved the use of local lamps almost exclusively with the possible exception of a few isolated general lighting units for providing a low intensity over the passageways and storage spaces. Modern practice, however, involves the use of a fairly high intensity of general light, well diffused and well distributed over the entire work area. It is not to be expected, however, that every operation in the machine shop can be illuminated satisfactorily by the general lighting system. Recourse must be had to extension lights in such operations as working inside of deep borings or castings. These, however, are special cases, and are by no means general. A typical layout for a machine shop is shown in Fig. 7. It will be noted from this plan that special attention has been accorded the work benches along the windows which ordinarily cannot be lighted by means



O-150 watt Mazda C Lamp in RLM Standard Dome Reflector.
⌑-100 watt Mazda C Lamp in RLM Standard Dome or Deep Bowl Reflector.

Fig. 7—Plan of Machine Shop

of the general system over the interior of the room. Good practice in such cases makes use of Mazda C lamps in RLM dome reflectors spaced on approximately 8 to 10 feet centers, depending upon the intensity desired, and mounted six feet about the table top.

A night view of a machine shop lighted by a straight general system of lighting is shown in Fig. 8.

It is often necessary when locating the outlets in such a room to slightly shift the units to one side or the other in order to clear such obstructions as pulleys, shafts, beltings, etc. Wherever pos-

Fig. 8—Machine Shop Lighted by 200-Watt Mazda C Lamps in R. L. M. Standard Dome Reflectors Spaced on 12 Ft. by 12 Ft. Centers and Hung 14 Ft. High. The Distribution Is Excellent As Can Be Noted From the Soft Shadows and the Intensity Is in the Neighborhood of Seven Foot-Candles

sible, however, the symmetrical spacing described before should be adhered to in order to insure an even distribution of light over the entire work plane.

The work carried on in the wheel shop is of a relatively coarse nature which can be easily illuminated by means of a straight general system of lighting, such as that shown in Fig. 9. Mazda C lamps in the RLM dome reflectors are spaced in the form of

squares so as to provide an even distribution of light over the work plane. The hanging height is sufficient to clear the tops of hoists, small cranes and other machinery. This, of course, will depend upon the ceiling height of the structure and other local conditions.

It is recommended that wherever possible, the walls, columns and ceilings be painted white or whitewashed in order to increase the light utilization in the room. This is particularly desirable in the case of forge shops where the surroundings are ordinarily dense black in nature, but is a practice not generally found. Not only is the lighting system considerably aided thereby, but better vision results from a contrast of brightness between the whitewashed portions of the room and the other machinery. Fig. 10 illustrates this point,

Fig. 9—A Wheel Shop Lighted by a General System of 500-Watt Mazda C Lamps in R. L. M. Dome Reflectors Spaced 17 Ft. by 15 Ft. and Hung 17½ Ft. High. The Intensity Is Such That No Drop Cords Are Needed or Used, 13 Foot-Candles Being Provided

and is a good example of careful maintenance. In the forge shop, too, the straight general system of illumination is applicable, the units being placed in the form of rectangles or preferably squares and then mounted not less than 12 feet above the floor for proper distribution of light.

206. Foundries

As a general rule, all the classes of work performed in foundries can be lighted by a general system with the exception possibly of bench-molding, machine-molding, and core-making, which operations call for some discrimination of details since the pieces are usually small and must be accurately molded.

The type of structure is somewhat similar to that of the other shops, and a similar system of lighting is recommended; that is, high wattage Mazda C lamps in RLM dome reflectors for general lighting supplemented by high wattage Mazda C lamps in elliptical angle reflectors mounted on the side walls below the crane level for providing light on the vertical side of the molds thus breaking up shadows enabling the operators to perceive the edge of the mold for patching and trimming. A medium intensity of light is advisable.

207. Freight Car Repair Shops

For the modern design of freight car repair shop, equipped with traveling crane, the general arrangement of the lighting is somewhat similar to that recommended for medium height erecting shops with longitudinal track layout with this important exception. In those shops where the cars are progressively built up as they move down the length of the shop it will be necessary, from an economic standpoint, to provide a low degree of general illumination over the entire floor area, supplemented by a higher intensity over the local work areas.

In small shops, or where it is the practice to do nearly all the work on one car at one location, a lighting system similar to that recommended for the medium height erecting shop can be used.

208. Round House Lighting

In spite of the extremely unfavorable conditions for lighting, round houses can be satisfactorily illuminated with adequate intensity and no objectionable glare. High roofs, well designed smoke-jacks, and whitewashed walls and columns will, of course, be of considerable assistance, reducing the wattage necessary for satisfactory results.

Fortunately, the majority of the work is confined to the limited space occupied by the running gear of the engines. Throughout the remainder of the house it is only necessary to provide sufficient illumination for safety and reasonably rapid movement of trucks and workmen. The primary consideration should be to install as many of the lighting units as possible below the smoke zone and at the same time to provide some illumination on the upper part of the locomotive.

There are two general methods at present employed in the lighting of engine houses. The first covers a distributed system with overhead lighting units located along center line of space between the stalls, directing the light downward towards the locomotives with a maximum intensity on the running gear. The other system employs equipment mounted on the rear walls and front columns, projecting the light horizontally along the stall. While the latter units are easy to install and can be conveniently maintained, the workmen, supporting columns and other objects will cast deep, heavy shadows which are not only objectionable but actually dangerous. This particular system has been condemned in some states as a violation of the Industrial Lighting Codes owing to the fact that it cannot meet at the same time the requirements for ade-

Fig. 10—An Up-to-Date Forge Shop Lighted by 200-Watt Mazda C Lamps in Shallow Dome Reflectors Spaced 20 Ft. by 30 Ft. Apart and Hung 15 Ft. High. Maintenance Is Carefully Looked After As Is Attested by the Painting of the Forges in Order to Provide Better Reflecting Surfaces

quate intensity and uniformity of illumination with no objectionable glare.

To fulfill successfully the lighting requirements in a round house, equipment must be provided throughout the stall. In addition to concentrating the maximum intensity on the running gear some illumination must be provided on the upper parts of the locomotive, particularly on the turbine generator. The most efficient results will be obtained from equipment mounted below the smoke zone as it will not only operate more efficiently but will usually be more accessible for cleaning. In some cases two mounting heights or even two different types of units will be necessary. In other installations one kind of unit mounted on the same level will be sufficient.

For satisfactory operation with adequate illumination for most work and insuring reasonable safety, from 4 to 8 foot-candles

should be provided on the vertical plane of the running gear and from ½ to 1 foot-candle of general illumination on a horizontal

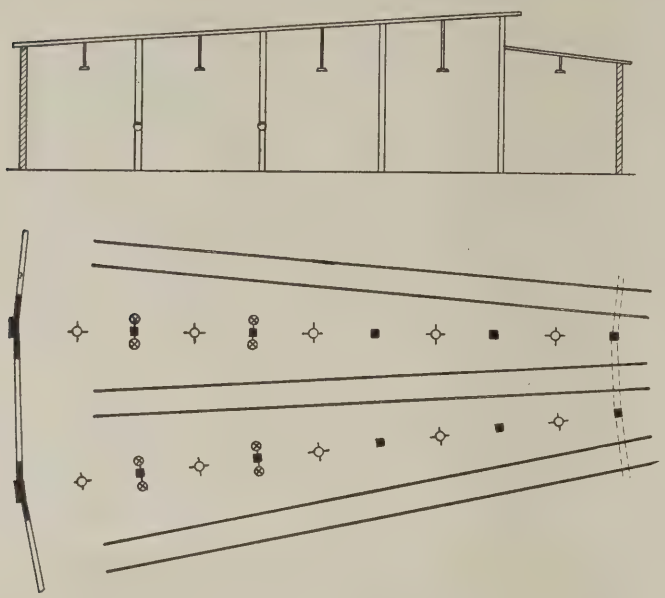

⊹ 200 WATT MAZDA C LAMP EQUIPPED WITH RLM REFLECTOR MOUNT 18'-0" ABOVE FLOOR.
⊗ 200 WATT MAZDA C LAMP EQUIPPED WITH ELLIPTICAL ANGLE REFLECTOR. MOUNT 8'-0" ABOVE FLOOR.
TOTAL WATTAGE PER STALL = 1800 WATTS

Fig. 11—Roundhouse Lighting Plan A

plane throughout the stall. In the aisle running around the rear wall, from 1 to 2 foot-candles should be provided.

Figs. 11 and 12 illustrate systems which have successfully ful-

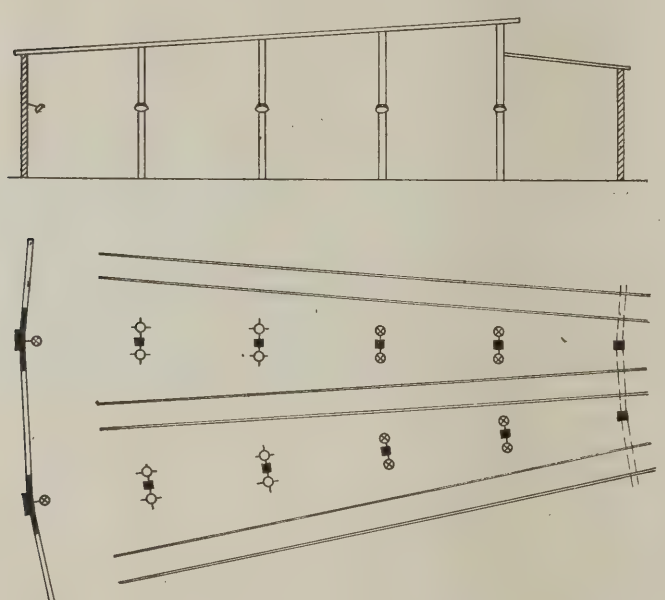

⊹ 200 WATT MAZDA C LAMP EQUIPPED WITH RLM DOME REFLECTOR. MOUNT ON ANGLE 12'-0" ABOVE FLOOR.
⊗ 100 WATT MAZDA C LAMP EQUIPPED WITH RLM DOME REFLECTOR. MOUNT ON ANGLE 12'-0" ABOVE FLOOR
TOTAL WATTAGE PER STALL = 1300 WATTS

Fig. 12—Roundhouse Lighting Plan B

filled the requirements for round house lighting. Outlets should be provided at frequent locations, however, for extension cords which will be necessary for lighting inside and under locomotives; also in providing sufficient light for exacting work. General lighting should not be expected to take care of every requirement and would be found too costly from the point of view of operating and maintenance costs.

In Fig. 11 general illumination is provided by 200-watt lamps in RLM reflectors between the columns and mounted 18 feet above the floor. In bays having traveling cranes it may be necessary to mount the units even higher. On the columns, 200-watt lamps in angle reflectors direct a maximum intensity on the sides of the engines. These should be mounted 8 feet above the floor and can be easily maintained in efficient condition. In Fig. 12 one type of unit lights both the running gear and the upper section of the locomotive. The success of this is dependent on the angle at which the unit is tilted as well as its mounting height. Experience indicates that a mounting height of 12 feet with unit tilted 30° from vertical gives best results. All of these units are readily accessible for cleaning. The lighting units can be installed as shown diagrammatically in Fig. 13. With extremely dirty and smoky condi-

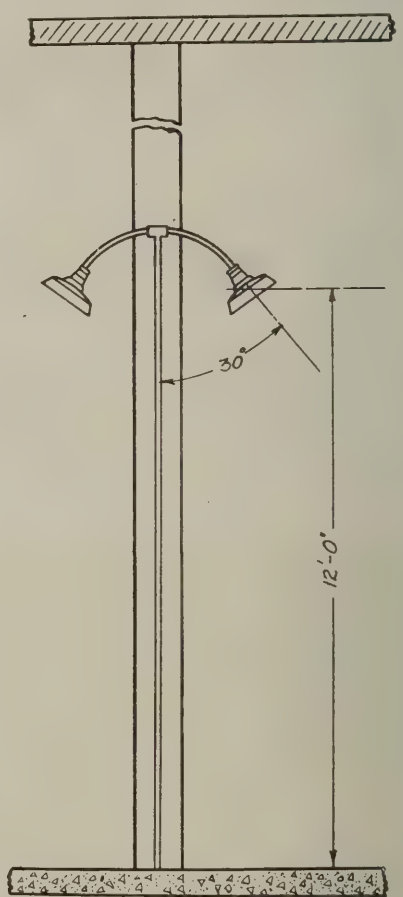


Fig. 13—Method of Mounting R. L. M. Reflectors on Angle for Roundhouse Lighting

tions enclosed equipment can be provided permitting cleaning merely by wiping off the glass cover plate. Heat resisting glass will allow the use of cold water swabs for this purpose. While the ordinary type of extension lamp is generally used for local lighting, much better results can be secured with a small portable projector type of unit such as illustrated in Fig. 14.

To obtain the most efficient results, the columns, pits and rear walls should be maintained in as light a condition as possible by whitewashing or painting at frequent intervals. Excellent results will be obtained if some light is directed on the rear wall, especially if maintained in white. In addition to serving as a well illuminated background the diffused light will aid materially in furnishing uniform illumination.

The success of any installation, however, is entirely dependent on maintenance. One employee should be delegated to wipe off each unit at least once a day, preferably in the middle of the afternoon. He should also be responsible for seeing that the proper lamps are used in each reflector.

The turntable should be illuminated by floodlights. A total of from 2000 to 3000 watts should be provided, using 500 watt projectors mounted on the roof of the round house. Where the engine house is less than a semi-circle, at least one of the projectors should be installed on the opposite side of the table.

209. Quick Method for Laying Out Shop Lighting Systems

In order to make easy the work of designing a general lighting installation such as that recommended for the low ceiling shops of

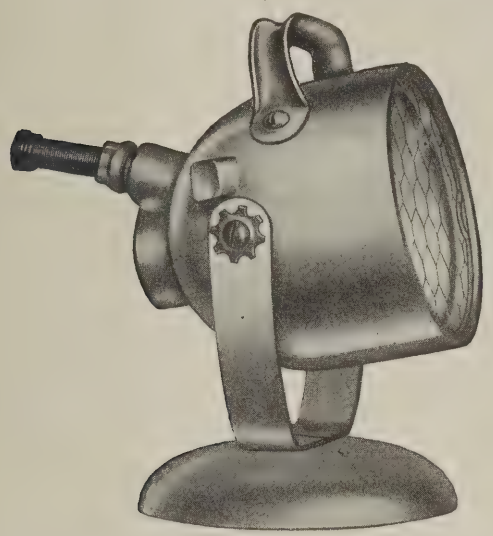


Fig. 14—Portable Projector for Local Lighting

which the machine shop is a good example, the curve shown in Figure 17 is given. The complete installation data as concerns intensity on the working plane, spacing distance of lighting units, height of units above working plane, etc., is given on this curve sheet and it is the work of but a few minutes to secure all the necessary data to design a general lighting system. The particular

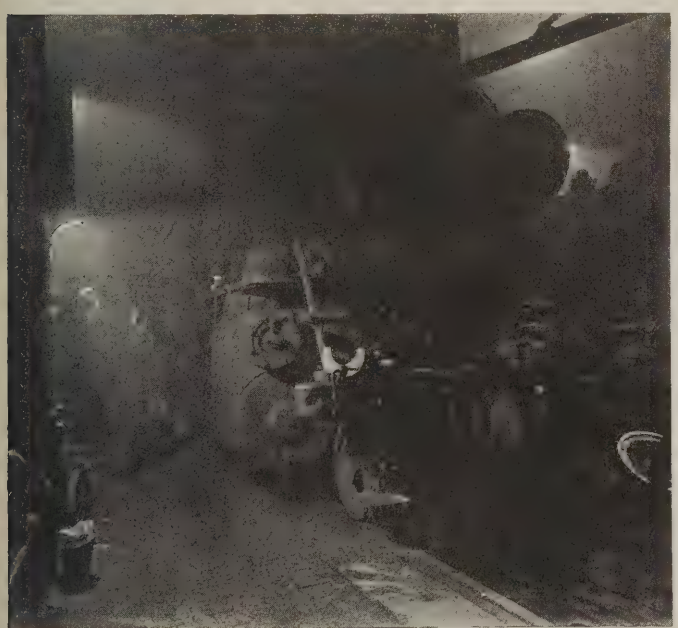


Fig. 15—Night View of Roundhouse Lighted by Combination of Overhead and Angle Reflectors

curve shown refers to the use of clear Mazda C lamps in the RLM standard dome reflector. The general working formula from which this curve was derived is shown in the lower lefthand corner and reads,

$$I_h = \frac{\text{Lumens} \times 0.4}{\text{Area}}$$

"I_h" indicates the intensity on a horizontal surface, the lumens referred to are those emitted by the lamp which can be secured from the manufacturer's data book rating. The 0.4 is a constant called the coefficient of utilization, and the area referred to is the area of the square or rectangle which each particular lighting unit illuminates.

The curve sheet is used as follows:

Assuming that Mazda C lamps in RLM dome reflectors are to be used to secure the illumination desired, the next step is to determine what intensity of light is required for the particular work carried on in the room. This intensity can be secured from Table I, Section I. Assuming that an intensity of 6 foot candles is desired, the next step is to determine the ceiling height of the room to be illuminated. Assuming that it is 16 feet, from this ceiling height of 16 feet, two feet are subtracted to allow for the suspension of units from the ceiling and an additional 2½ feet are also subtracted to allow for the height of the working plane above the floor level. This will leave a total of 11½ feet which is the height of the lighting units above the working plane.

Knowing the desired intensity, 6 foot candles, and the height of the lighting units above the working plane, 11½ feet, we are in a position to use the curve as follows:

On the vertical scale shown to the left of the curve sheet pick off the 6 foot candle line and trace it over horizontally. On the horizontal scale marked, "Height of unit above working plane",

Fig. 16—Night View of Roundhouse Lighted with R. L. M. Reflectors Tilted on an Angle and Mounted on Columns

pick off the 11½ ft. point and trace this line up vertically. Where these two lines intersect is found the size of lamp required to give the desired illumination. In this case it will be the 200-watt lamp since this curve lies a trifle nearer to the intersecting point than does the 150 watt lamp.

The proper spacing distance between units can then be found by tracing the vertical (hanging height) line down until it intersects the horizontal scale marked Spacing Distance. The nearest even figure should be used.

Below the spacing distance scale will be observed an area scale. This is for the purpose that, should a square arrangement of lighting units be impossible, a rectangular arrangement can be used with the area of the rectangle equal to that of the square just found.

The illumination of vertical surfaces, such as those encountered in the erecting shop and round house is special in nature and calls for careful consideration of the factors which govern the design of the lighting system. In such structures as erecting shops the vertical illumination of the sides of the locomotive is ordinarily provided by means of elliptical angle reflectors mounted on the side walls of the structure in such a fashion as to direct most of the light on the surfaces mentioned.

The proper design of a lighting system employing elliptical angle reflectors is quite tedious, inasmuch as the calculation must necessarily be based on the point by point method instead of the flux of light method ordinarily employed for designing a system used for illuminating horizontal planes.

The design of a suitable system employing elliptical angle re-

flectors is further complicated by the fact that common practice in railroad erecting shops places the tracks parallel to the long side of the structure which means that there are two or more parallel vertical planes represented by the sides of the locomotives which must be illuminated by the same lighting unit mounted on the side walls.

This is a rather complicated condition, inasmuch as the common case is to have but one vertical plane to be illuminated such as in the round house, where the side of each locomotive has its own individual lighting installation.

In order to render easier the task of designing a system using elliptical angle reflectors, the curve sheet shown in figure 18 is given. In view of the fact that there are a number of vertical planes arranged tandem fashion in the erecting shop, it is necessary before using this curve to make certain assumptions which should not, however, materially alter the desired results. In applying this curve sheet it should be remembered that there is a definite limit to the distance at which any working plane can be illuminated by means of elliptical angle reflectors. Because of the pronounced distribution of light in a particular direction, from these units it is obvious that the farther away the illuminated plane is located, the higher must the lighting unit be hung, in order to effectively light this working plane. Because of this fact the intensity of illumination provided at any point on a vertical plane falls off very rapidly as that plane is removed from the lighting unit.

Reliance must, therefore, be placed upon the judgment of the people using this curve sheet in choosing the average work plane which is to be illuminated, and then designing the system so as to illuminate this hypothetical plane. If this is done it will be found that the resulting illumination will be of good character over the actual working planes.

With this in mind the curve sheet is used as follows:

Knowing the intensity of illumination which is desired, and the

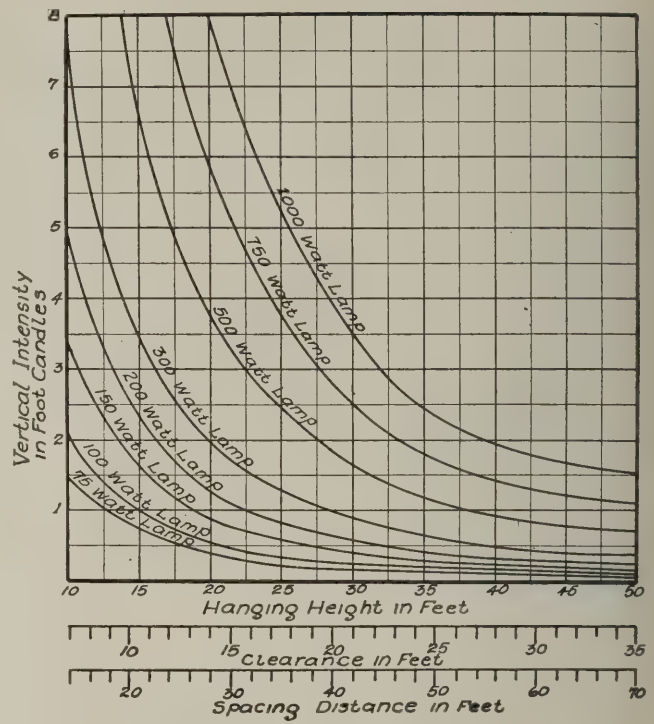


Fig. 18—Curves Showing the Relation Between Vertical Intensity, Hanging Height, Clearance and Spacing For Various Sizes of Clear Mazda C Lamps in Elliptical Angle Reflectors

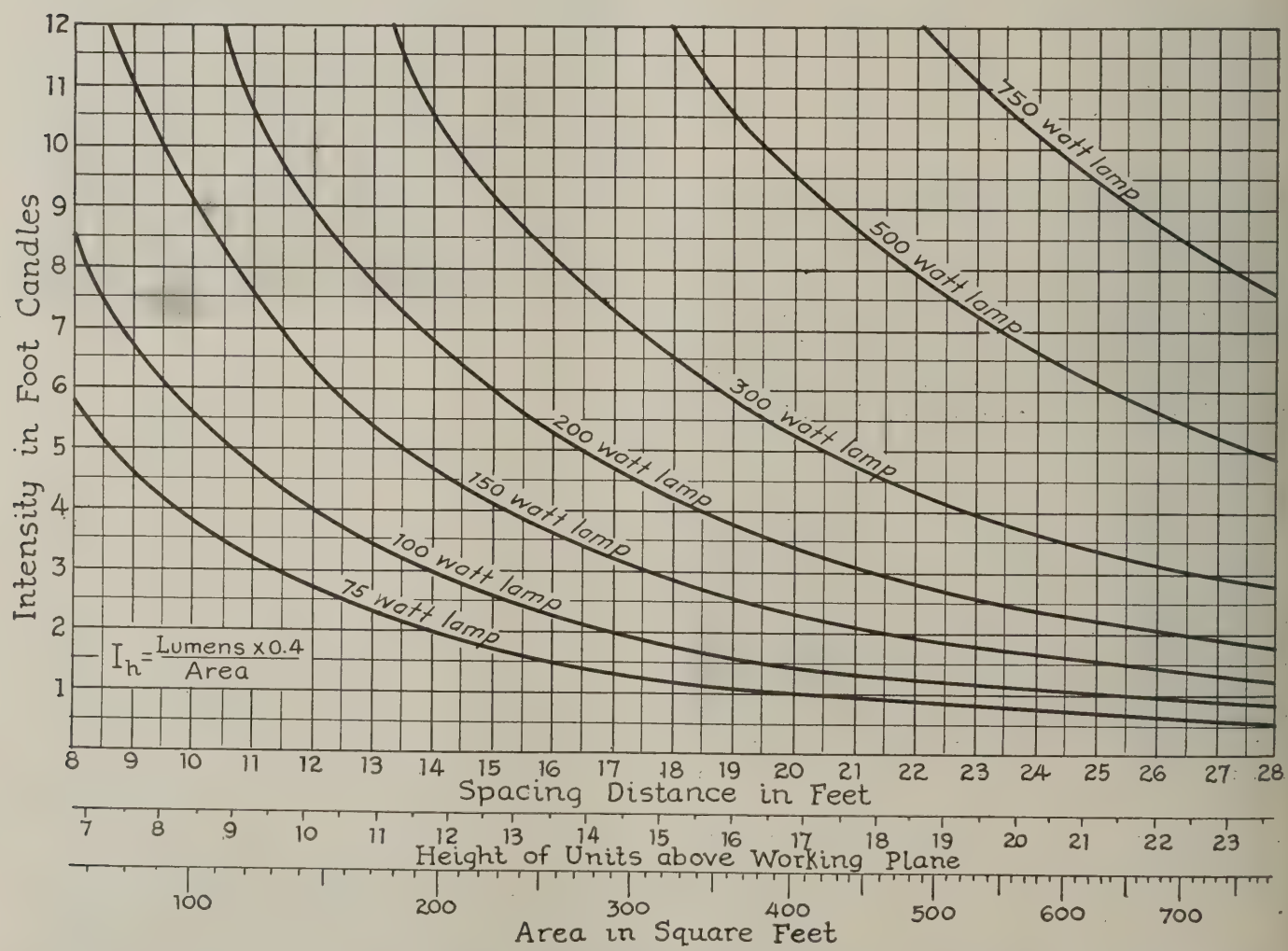


Fig. 17—Curve Showing Relation Between Intensity, Hanging Height and Spacing Distance for Various Sizes of Clear Mazda C Lamps in R. L. M. Dome Reflectors

distance between the plane to be illuminated and the line of lighting units, which is referred to as the clearance, the horizontal line representing the correct intensity is traced over until it meets the vertical line representing the clearance and the nearest lamp to this intersection is the correct size of lamp to use. Where the vertical line representing the clearance between lighting units and illuminated planes intersects the hanging height scale will be found the correct height at which to hang the units, and below the clearance scale will be found the spacing distance in feet, which distance will be indicated where this same vertical line prolonged, intersects the spacing distance scale. As a practical example, assume an erecting shop where the tracks are arranged in longitudinal fashion, i.e., lengthwise throughout the shop. The width of this shop is supposed to be 40 feet. If the hypothetical plane to be illuminated is chosen as occupying the center line of the shop, the clearance from lighting units will then be half of 40 or 20 feet. Suppose an illumination of 4 foot-candles is desired on this plane. Tracing over the 4 foot-candle line until it meets the 20 foot clearance line the intersection will be found near the 1,000-watt lamp curve, indicating that 1,000-watt lamps should be used. The vertical 20 foot clearance line intersects the hanging height scale at approximately 27 feet, indicating that the unit should be hung 27 feet high. Below this the vertical clearance line will be found to intersect the spacing distance scale at 40 feet indicating that the spacing between lighting units is 40 feet. We then have the complete installation data. In order to secure the 4 foot-candles on the vertical plane at the center of the shop, 1,000-watt Mazda C lamps should be used in elliptical angle reflectors hung 27 ft. high and spaced 40 feet apart.

Of course the intensities on vertical planes nearest to the lighting units will be higher than 4 foot-candles, while those located farther away from the lighting unit than 20 feet will be lower than 4 foot-candles. Furthermore, since these curves are based on the point by point method of calculation, they represent the minimum intensities which will be secured in practice. Actually somewhat higher intensities will be obtained, due to the light reflected from other surfaces, such as the walls, ceilings, etc.

In using this curve sheet for shops in which the tracks run crosswise, the same method should be used, and the results, while not being as good as those obtained in the class of shops first mentioned, will be as good as can be expected with such an arrangement.

In extremely wide erecting shops, it will be necessary to use two rows of elliptical angle reflectors, mounted on each side wall, one row illuminating the area nearest the wall, while the other illuminates the area in the center of the shop. The same method should be used in each case after choosing the proper hypothetical plane to be illuminated.

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Report of Committee on Locomotive Electric Lighting

Lamps, Roller Bearings and Other Equipment Are Still in the Process of Experimentation and Development

Committee:—

L. C. Muelheim, chairman, chief headlight supervisor, Baltimore & Ohio Railroad; J. L. Minick, assistant engineer, Pennsylvania System; P. J. Callahan, supervisor, car and locomotive lighting, Boston & Maine Railroad; E. Wanamaker, electrical engineer, Chicago, Rock Island & Pacific Railroad; F. J. Hill, chief electrician, Michigan Central Railroad; William Kirsch, chief electrician, New York Central & St. Louis Railroad.

TO THE MEMBERS:

Your Committee has been unable to hold any meetings since the June convention owing to the time of some of the members being occupied by matters of a pressing nature in connection with their railroad operation, although the various subjects being handled have been further investigated and developed.

The matter of headlight photometry remains substantially as it was up to the June meeting, as the different methods in use by the various reflector manufacturers continue to be considered by them as the proper methods. Your Committee feels, therefore, that better progress toward a solution of this problem could be made if a joint meeting between this Committee and representatives of the reflector manufacturers be held, at which meeting the reasons for the differing methods could be fully brought out and considered and the Committee could then be in position to make definite recommendation as to the system to be used. It is recommended, therefore, that such a meeting be arranged for at as early a date as consistent following this convention.

Headlight and Cab Lamps

Considerable development work has been done by the lamp companies during the past few months on both headlight lamps and cab lamps, and while certain new features have been developed, considerable improvement has also been noted in performance of the standard 250-watt, G-30 bulb headlight lamp, indicating that the manufacturers have made some progress toward overcoming the weaknesses which in the past were the cause of unsatisfactory lamp life.

The Committee has received very little comparative data from the various roads in connection with trials of the newly developed lamps, as was hoped, in order that as much reliable information as possible might be obtained relative to the desirability of the smaller bulb lamps. Some trials have been made, however, one road finding the 250-watt, P-25 bulb headlight lamp giving somewhat better life performance than the same lamp in the G-30 bulb, while it is learned that another road has adopted the S-14 bulb cab lamp after having conducted service tests with this lamp compared with the S-17 lamp. Two of the other roads, in tests conducted, found the smaller bulb lamp not so satisfactory in life performance. The lamp manufacturers, however, have recently made further developments toward improvement in the S-14 lamp, and it is recommended that more extensive investigation and trial by the railroads be given the smaller type of lamps during the coming months. In the meantime it would be of great assistance to the Committee in its work and to the manufacturers in their development of the new types of lamps if the members would send to the Committee any information they may have obtained from a trial of these lamps or to state during discussion of this report what experience has been gained.

A new double filament feature has recently been developed in headlight lamps for road service. Only a few of these, however, are as yet in actual service and it will probably be some little time before the merits of this development will be known. The lamp is a G-30 bulb with a 250-watt major filament, in one coil, supported horizontally between the two lead-in wires, and a 50-watt minor filament, similarly coiled, and mounted beneath the major filament. The minor filament is designed to operate at a somewhat lower efficiency than the main filament, continuing to burn after the main filament fails, and providing an emergency headlight of considerable power for the remainder of the run without the necessity of stopping to apply a new lamp.

It is noted that a variety of voltage in headlight lamps and cab lamps is in use. Your Committee feels there is no particular advantage to be gained from lamps of slightly different voltage from the standard 32-volt rating, as the generators can ordinarily be adjusted to suit the desired voltage. This variety of voltages is particularly objectionable from a manufacturing standpoint, and demand for special voltage lamps is a practice tending away from the idea of standardization, which is the present desire in general industrial lines to cheapen and simplify production. It is strongly recommended, therefore, that the railroads adopt and standardize on the 32-volt lamps for headlight and 33-volt lamps for cab lighting service.

Fixed Focus for Headlights

There are quite decided views on the fixed focus principle, but as the matter has as yet been given so little actual trial, information from experience with the practice is lacking, and your Committee is so far not in position to make a recommendation on the subject. The matter will be given further consideration, and as certain roads have indicated that the idea would be tried out by them, it is hoped the results of their experiments will be made known to the Committee as soon as consistent.

Turbo-Generator Bearings

Roller bearings for headlight generator service continue to give satisfaction in a limited number of service tests where they have been tried. One of the turbo-generator manufacturers has extended the field of tests being made on this type of bearing to include all classes of railroad headlight service, which was felt to be warranted by performance of roller bearings placed in test service at the beginning of the experiment. An accurate record is being kept of all the test equipments, which have been started at various dates, one installation having now operated continuously for 22 months and is still in good condition. The present intention of this company is to continue these tests for several months, at the end of which time it is expected some interesting and valuable data will have been collected and upon which a decision on the type of bearing for future use can be based.

Insulated Wire for Locomotive Use

Your Committee feels that the matter of wire for locomotive service should be again taken up and investigated further, with a view to developing a more generally satisfactory wire for this service than has so far been produced. There has been a wide variety of types of wire used on locomotives since the introduction of electric lighting in this field, and with the increasing application of automatic train control equipment the situation will no doubt tend to become still more chaotic. The feeling is rather general that a satisfactory wire has not yet been developed, and it is believed an improvement and a more general standardization can be brought about by the Committee taking the matter up for thorough investigation.

Generating Unit for Automatic Train Control Equipment

It is felt that in view of the largely experimental stage of automatic train control equipment at this time, it is a little early to begin actual development of a specification for a generating equipment for supplying power for the locomotive lighting and train control equipment, except perhaps in a very general and elementary way. The subject, however, should be kept before the Committee and as development of the equipment progresses its various phases should be studied carefully so that the benefit of actual conditions of operation may be taken advantage of and form the guide for development of a specification at such time as this becomes advisable. The Committee on Automatic Train Control no doubt has the general subject thoroughly in hand, but on the features of the train control equipment which affect, or are affected by the locomotive headlight equipment, it is possible the Headlight Committee can be of some assistance in developing the matter and will be glad to co-ordinate its efforts with those of the Train Control Committee toward a solution of such problems.

Respectfully submitted,

COMMITTEE ON LOCOMOTIVE ELECTRIC LIGHTING.

Report of Committee on Safe Installation and Maintenance of Electrical Equipment

A Summary of Various Protective Steps Suggested to Eliminate Injury From Electrical Circuits

Committee:—

Chas. R. Sugg, chairman, electrical engineer, Atlantic Coast Line Railroad; L. F. Miller, road foreman electrician, Chesapeake & Ohio Railroad; Frank Zimkowski, car lighting inspector, New York, New Haven and Hartford Railroad; A. M. Frazee, electrical engineer, Duluth, Missabe and Northern Railroad.

TO THE MEMBERS:

This report is intended to lay particular stress on the safety features involved in the installation and maintenance of electrical equipment and apparatus. The National Electric Code and the National Electric Safety Code being used as the basis.

Installation

GENERAL

First:—All new work should be installed in the safest way possible.

Second:—Existing installations should in all cases be brought up to safety standards, as soon as practicable.

Third:—All work must at least conform to the National Electric Code, and local ordinances.

Fourth:—In all cases, where ground connections are required, it is recommended that these connections be made to a cold water pipe, which is known to form a permanent and positive ground. If a cold water pipe is not accessible, it is recommended that a ground connection be made by driving not less than a three-quarter inch galvanized pipe or its equivalent in the earth a sufficient depth to insure a permanent ground. If the nature of the soil does not insure a permanent ground by the foregoing method, the specifications for artificial grounds as given by the National Electrical Safety Code is recommended (published by the Bureau of Standards, Washington, D. C., and is obtainable from the Superintendent of Documents). In all cases, approved ground clamps must be used.

Fifth:—It is recommended that all new inside installations shall be made in conduit, or approved armored cable, and when extensive repairs are made to old installations of open wiring, conduit shall be substituted.

Sixth:—It is recommended that all high voltage wiring (601-5,000) shall be in lead covered or armored cable run in conduit, where used for interior work.

Seventh:—The term "conduit" used in this report includes all kinds of metallic conduit.

Eight:—Where any installation is not covered by the above, use good judgment to make it safe.

EQUIPMENT AND MATERIAL

First:—Use good reliable equipment, which as far as practicable, incorporates safety devices, which will protect both operator and equipment.

Second:—In consequence of liability involved by accident, primary consideration should be given to the safety features rather than to the first cost.

GENERATORS

First:—All electric generators and supply equipment shall have the exposed non-current carrying metal parts permanently grounded. This to include frames of generators and switchboards

cases or transformers, lightning arrestors, enclosed switches and operating levers. This rule not to apply to the frames of direct current apparatus, having one pole grounded.

Second:—Flywheels and belts should be guarded. Flywheel pits should either be covered or guarded.

SWITCHBOARD—Power panels or sub-stations—(not distribution panels).

First:—Systems above 300 volts should be of a dead front type.

Second:—All switches on circuits above 300 volts should be of the oil type, should preferably have separately contained cells for each pole, and have proper disrupting capacities, in order to insure the performing of its functions with safety, and properly protect the apparatus to which they are connected.

Third:—Automatic overload circuit breakers should be installed, between generator and switchboard busses on direct current equipment, but it is deemed advisable to omit these features on alternating current systems.

Fourth:—All feeder circuits should be protected with automatic inverse time limit overload oil switches.

Fifth:—Switchboards should be so installed that there will be ample space, between conductors and wall, to permit workmen to make repairs with safety; this space to be enclosed behind locked doors.

Sixth:—All switchboards not provided with dead fronts should have rubber mats in front and rear of same.

Seventh:—Fuses are not recommended where automatic circuit breakers can be used.

MOTORS AND CONTROL EQUIPMENT

First:—At least strict conformance to the National Electric Code and local ordinances is recommended.

Second:—Each equipment should be provided with separate safety disconnecting knife switch to disconnect both control and motor from line so repairs can be made with safety.

Third:—All controllers with exposed live parts should be enclosed in safety cabinets with doors so arranged that only authorized persons shall have access to same.

Fourth:—Motor starting rheostats should be enclosed in metal cabinets with handles for external operation.

Fifth:—All protective devices used in connection with motor control apparatus should be provided with full magnetic or thermal overload and under-voltage protection with hand reset, excepting automatic equipment.

Sixth:—Where motors are so installed, that there is a liability of accident, adequate guards should be placed around same to protect workmen. This to include belts, gears or other transmitting devices.

Seventh:—Hand operated starters and push buttons of remote control starters should be within sight of the equipment controlled, unless such equipment is within an enclosure.

Eighth:—The frames of all motors, and each piece of control equipment, must be thoroughly grounded.

Ninth:—Caution placards admonishing danger should be conspicuously placed at such a location, as to warn employees and others of the presence of high voltage and equipment.

WIRING

First:—At least strict conformance to the National Electric Code and local ordinances is recommended.

Second:—It is recommended that all new installations be in conduit.

Third:—When used in connection with portable cords, it is recommended that composition or other well insulated sockets of the keyless type be used, in connection with well constructed guards, provided with handles of wood or other insulating material.

Fourth:—On power circuits adhere strictly to the National Electric Code at least, and local ordinances.

Fifth:—For portable equipment rather than small hand lights, it is recommended that armored cable or additional wire be used for grounding machine. Where armored cable is used the armor must be so connected that it shall form a grounded connection to the conduit system.

Sixth:—For the installation of high voltage equipment, all wiring shall be in lead covered or armored cable run in conduit.

Seventh:—The installation of extra high potential circuits is adequately covered by National Electric Code.

Eighth:—It is recommended that in wiring for lighting circuit, the number of outlets on any branch circuit shall not exceed 7, and should preferably be limited to 6. This number of outlets is limited because experience has proven that it is a very hard matter to prevent the application of higher wattage lamps than that for which the circuit was originally intended.

Ninth:—It is recommended that where practicable, the wiring of all single phase main lighting circuits above 60 amperes shall be wired as a three wire system, using an unfused, grounded neutral. Branch circuits may be run either as two or three wire systems.

Tenth:—The use of fuses for protection of motors and control is not recommended.

Eleventh:—(a) Entrance and branch line fuses must be provided as required by the National Electric Code, but where it is practicable to install circuit breakers they are preferred. The selection of circuit breakers to be governed by local conditions. (b) In lighting circuits the use of fuses is satisfactory where installed according to the National Electric Code. (c) The capacity of fuses should never be in excess of the capacity of the wire, which they are to protect. (d) One time or refillable fuses. It is recognized that both types of fuses when properly installed and maintained will perform the functions for which they were intended. It is further recognized that both types have characteristics both favorable and unfavorable, and the type of fuse to be used depends largely upon local conditions and the class of supervision and inspection maintained. This committee does not deem it advisable to recommend either type exclusively, as either type will protect both operator and equipment when properly installed and maintained. (e) All switches shall be so designed that when installed the blades will drop open, and when of the fused type the fuses must be on the hinged end of switch. In this design of switch the blades and fuses will be dead at all times when switch is open.

Maintenance

First:—In the maintenance of electrical equipment, it is recommended that thorough systematic periodic inspection be made and if any improper or irregular condition be found it shall be repaired immediately.

Second:—Equipment should be kept thoroughly dry and clean.

Third:—When inspection is made, it should include the supports sustaining the equipment, which should be kept secure and rigid. All power transmitting devices, such as belts, gears and etc., should be included in this inspection.

Fourth:—The inspector should see that all circuits are properly fused and overload relays adjusted and operative.

Fifth:—For the safety of repairmen or others, the following suggestions are offered: Don't work on live circuits, except when absolutely necessary, then take proper precautions. Don't work on high tension apparatus until you are sure it is positively disconnected from line and grounded. Don't place tools or other loose objects, where they are liable to fall and cause damage or accident. Don't feel a circuit to see whether it is alive or not, but use lamps or meter instead. Don't oil, wipe or adjust machines while in motion.

Resuscitation

It is recommended that in case of a severe electrical shock the Prone Pressure Method of Resuscitation as prescribed by the Commission on Resuscitation from Electric Shock, be adopted and that placards similar to No. 1352 issued by National Safety Council, Chicago, showing the method of application and treatment, be framed and conspicuously displayed at prominent locations throughout the shops. It is further recommended that all foremen in the shops thoroughly acquaint themselves with this method of resuscitation, and that the employees generally be encouraged to practice this method according to instructions. A pamphlet containing rules of resuscitation can be obtained from the National Electric Light Association, 29 West 39th street, New York, at a nominal price.

The committee desires to especially thank Mr. Geo. T. Johnson, assistant engineer of New York, New Haven and Hartford, for the constructive criticisms offered.

Respectfully submitted,

COMMITTEE ON SAFE INSTALLATION AND MAINTENANCE OF ELECTRICAL EQUIPMENT.

Report of the Committee on the Application of Radio to Moving Trains

Installations and Tests Made on Private Cars on Transcontinental Runs

Committee:—

S. D. Dimond, chairman, chief electrician, Minneapolis, St. Paul & Sault Ste. Marie; F. O. Marshall, assistant Superintendent of Yard Department, Pullman Company.

To the Members:

This year's report covers:

1—General developments of the year.
2—Broadcast reception on moving trains;
(a)—Description of various installations;
(b)—Equipment available and suggestions pertaining to installation.
3—Dispatching and emergency communication.
4—Locomotive to caboose communication.

The response of railway men to our request for information regarding their experimental installations was not as good as expected, only a small number replying to our request for a report. No report was received covering installation of receiving sets for the use of passengers, although we understand some roads are using them for this purpose.

Practically all of the reports received related to installations on private cars and temporary installations in chartered cars or special trains. The manufacturers have been doing considerable work along the lines covered by this report and were kind enough to furnish very full reports of the results of their tests, with descriptions of the apparatus used.

(1) General Developments of the Year

Much progress has been made during the year just past in the development of more sensitive and more selective receiving sets, better amplifiers and better reproducing loud speakers.

The superheterodyne has been improved to such an extent that it is now easily operated and several manufacturers are offering models of this type of set suitable for railway use. The type of set using several stages of tuned radio frequency (of which the Neutrodyne is an example), with some method of eliminating or controlling the tendency of radio frequency amplifiers to oscillate, has also been developed and is now available for railway use. The reflex type of set, using tuned radio frequency (of which the Inverse Duplex is an example), has been improved and is also suitable for railway use.

The quality of received speech or music has been much improved by the more general use of "C" batteries, better amplifying transformers and "push pull" amplifiers for the last audio frequency stage.

The antenna equipment has been much simplified and in no case reported has a loop been used successfully for railway work. Sets ordinarily intended for use with a loop are used with a simple single wire antenna.

(2) Broadcast Reception on Moving Trains

(a) Description of various installations:.

A Permanent Installation

The Pullman Company has made a permanent installation of a radio receiving set on the Seaboard Air Line private car "Baltimore."

A "Radiola" six tube super-heterodyne, manufactured by the Radio Corporation of America, is mounted upon a table, as shown in the illustration, Fig. 1. The table is specially constructed and supported on two removable legs on one side and provided with standard Pullman table hooks on the other. The set is placed upon a sponge rubber mat about one-half inch thick, which serves to reduce the effect of vibration when the car is en route.

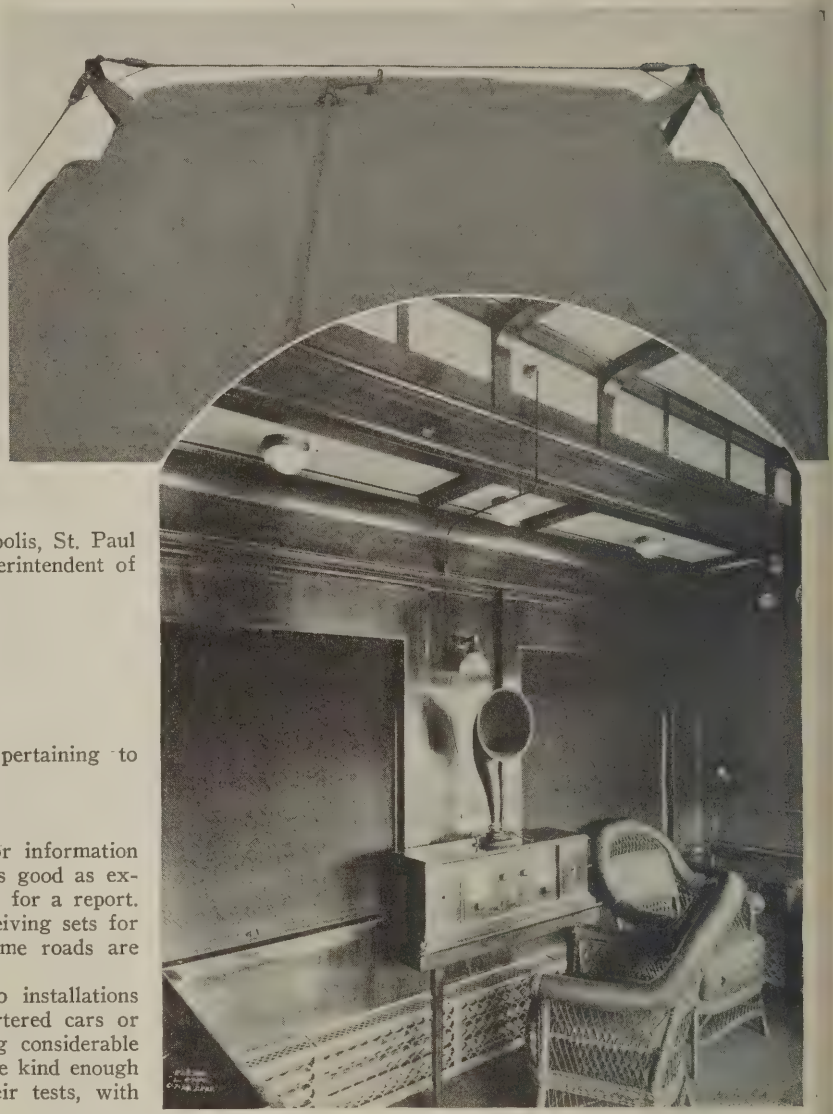


Fig. 1—Showing First Permanent Pullman Installation

The loud speaker is also manufactured by the R. C. A.

In order that the occupants of the rooms might listen in after retiring, a circuit was run to all the rooms and jacks provided for phone or loud speaker connections. These are brought out at a jack near the receiving set so that connection to the set can be made when desired.

The antenna is in the form of a single wire flat loop fastened to brackets on the car roof and supported by adjustable strain insulators as shown in the photograph. The wires are about 15 inches above the lower deck and 9 inches out from the upper deck. The circuit was made continuous at the corners by means of jumpers carefully soldered. The brackets were made of flat steel 3/16-inch thick and extended about 9 inches horizontally from the edge of the upper deck.

Connection was made to the receiving set by means of a wire soldered to the aerial and run directly to a standard lead-in insulator installed in the upper deck as shown in the interior view. A standard lightning arrester, mounted on the outside of the upper deck, is connected to the lead-in wire and grounded to the steel car. Inside the car, a solid No. 8 rubber covered wire was run from the lead-in insulator to a jack-box placed above the moulding immediately over the center panel. The connection from the jack, inserted in the jack-box, to the set is a piece of flexible cord.

This set is reported to give good reception and on the first trip market reports, baseball scores, and other broadcast material

was received on the loud speaker from Chicago, 200 miles distant. Pittsburgh, Cleveland and Toledo were also heard. This was in June, when reception is not at its best.

No interference was experienced from fans or car lighting generators, but the signals would cut off momentarily when the car passed under a steel bridge or power lines and sometimes

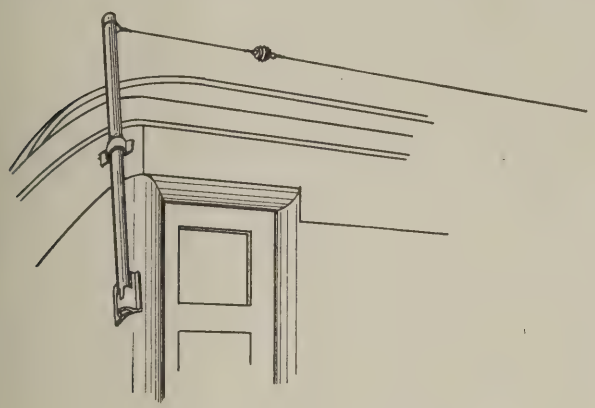


Fig. 2 Showing Temporary Antenna

crossing bells ringing could be heard, but not enough to spoil reception.

The Seaboard Air Line official reporting on the installation expressed himself as being very much pleased with results.

A Temporary Installation

A very interesting temporary installation was made, by the Radio Corporation of America, to the Famous Players-Lasky Corporation private car "Boston."

The receiving set was a Radiola Super VIII, six tube super-

Fig. 3 Neutrodyne Used in Transcontinental Test

heterodyne, with a built-in loop and loud speaker. It was placed in the observation end of the car and secured to the steam pipes to keep it from moving around when the train was in motion.

The antenna was a single No. 14 stranded wire, 75 feet long stretched between two posts and attached to a small electrose ball insulator at each end. Another electrose insulator was placed on a small rod clamped to a pipe on the car roof and used to support the wire at its center, to keep it from sagging. The posts were made of wood and inserted in the lamp brackets at either end of the car, as shown in the drawing, Fig. 2.

The antenna was thus held about one foot away from all metal on the roof.

The lead-in was brought in through the whistle cord hole and connected to the negative side of the "C" battery.

A lightning protective device was mounted inside the lower cabinet with one terminal connected to the antenna and the other grounded on the car pipe system.

When the car was moved from the Mott Haven Yard, where the installation was made, it was next to the electric locomotive. A small amount of noise was picked up in the set due to the motors in the locomotive, but other electric locomotives passing on the next track did not affect the receiving set in the least. Later on in the test, on the run from New York to San Francisco, the car was placed next to a head end dynamo car and, contrary to expectations, no interference was experienced from this source.

Some interference was experienced leaving New York City over electrified track, but upon changing to a steam locomotive at Harmon, N. Y., this trouble disappeared. The only other peculiarity of reception noticed on the trip across the continent, not common to stationary receiving sets, was the momentary fading out of stations when passing steel structures and other trains.

On the entire trip from New York to San Francisco, stations located in the following cities were heard: New York City, Pittsburgh, Schenectady, Philadelphia, Springfield, Chicago, Detroit, Elgin, Davenport, St. Louis, Kansas City, Omaha, Los Angeles, Portland, Oakland, and San Francisco.

The reception was of good volume and quality on the loud speaker, and was considered successful in every way.

A Neutrodyne Test

A Fada Neutrodyne receiver was tested by the manufacturers in a run from New York to Chicago over the Pennsylvania, and from Chicago to San Francisco over the tracks of the Chicago & Northwestern, Union Pacific and Southern Pacific lines. As the test was of a technical nature, the receiver was installed in a private drawing room.

The antenna consisted of two single No. 14 weather-proof copper wires running lengthwise on each side of the Pullman car, being fastened through small metal clips soldered to the side ventilators. The insulated wire accordingly laid in fourteen instances directly on the steel covering of the car. The two wires running lengthwise were connected together at one end, the connecting wire lying directly on top of the metal car roof. The lead-in was taken from the center point of this connecting wire, and run through a ventilator into the drawing room. In effect, the antenna was approximately sixty feet long, having in reality no appreciable effective height above ground. The resulting high electrostatic capacity would cause broad tuning and loss of signal strength, but good results were obtained in spite of this fact.

As soon as the set was installed local stations WHN and WJZ New York City, WOR Newark and WEAF New York City were received while the car was in the Sunnyside yards of the Pennsylvania at Long Island City.

No stations were tuned in while passing through the East River tunnel, but all four stations were again tuned in while the train was stationed underneath the thousands of tons of steel in the terminal. In going through the Hudson River tunnel no signals could be heard, except in one instance where the antenna passed directly beneath a vertical ventilator opening, at which time signals from WOR in Newark came in with exceptional volume, but immediately died and in a period of five or ten seconds became inaudible until the western entrance of the tunnel was reached.

No attempt was made to listen to a large number of stations in a given period, the idea being rather to listen to a given powerful broadcasting station for some length of time. On the

balance of the trip programs were listened to on the loud speaker from KDKA Pittsburgh, 260 miles distant, through interference from a rain storm and car generator; WGY Schenectady; WSAI Cincinnati, 435 miles distant; WMAQ Chicago, 500 miles distant; KFKX Hastings, 1000 miles distant; WJAX Cleveland; and WGN Chicago, 475 miles distant.

A particularly interesting fact was that station WGY Schenectady was tuned in and held on the loud speaker while going around the Horseshoe Curve at Kittanning Point, Pa., and no decided variation in signal strength was noted, except for a period of five to ten seconds, when signals died to inaudibility, but immediately came back to their former strength. With so many possible variable factors, such as the directional effect of the antenna, the masses of steel of the train, the body of water just below and the mountains above, a decided variation in signal strength would be expected in changing the receiving antenna position so greatly with respect to the antenna at the broadcasting station.

The receiving set used is shown in the illustration, Fig. 3.

(b) Equipment available and suggestions pertaining to installation:

Several types of sets suitable for broadcast reception on trains are now available. Those here listed have been used successfully in railway tests and are representative of the three types of sets now in most general use: the super-heterodyne, tuned radio frequency, and inverse duplex (reflex) sets.

Radiola Superheterodyne, manufactured by Radio Corporation of America.

Super Heterodyne No. 6004-B, manufactured by the Western Electric Company.

Fada Neutrola No. 185-A, manufactured by F. A. D. Andrea, Inc.

Monotrol No. 54, manufactured by the Sleeper Radio Corporation.

The selectivity of the new sets has eliminated to some extent the interference formerly experienced from car-lighting generators, fans and electrical sources outside of the trains' electrical equipment. It is suggested, however, that if interference is experienced from fans or generators, a one or two microfarad paper telephone or similar fixed condenser be shunted across the terminals of the offending machine. This method has also been successfully used to eliminate interference with reception on radio receivers located near crossing bells. In this case the condensers were shunted across the contacts of the bells.

Particular attention is called to the use of lightning arresters in connection with the installations described in this report. We recommend that all installations be made to conform to the "National Electrical Code" rules for radio receiving stations, as do the installations described.

Your attention is also directed to the fact that in the installations described no mention is made of ground connections to the receiving sets. It is not always necessary to use a ground connection with modern receiving sets, especially sets designed for loop operation and operated without the loop, using instead a small antenna. Sets of the inverse duplex type, operate in some instances without either loop or antenna, using a ground connection only.

Any one intending to make an installation would do well to study the Pullman installation described and illustrated above. This is adaptable to any type of car or set and the construction of the antenna and lead-in, as well as the arrangement of the set, is very near ideal.

(3) Dispatching and Emergency Communication

D. T. & I. Installation

The Detroit, Toledo & Ironton Railroad has an elaborate communication system consisting of three radio telegraph stations, located at Springfield, Ohio; Jackson, Ohio; and Dearborn, Mich. A printing telegraph automatically relays messages received at Dearborn to the factories of the Ford Motor Co. at River Rouge.

The station at Springfield operates on 1875 meters at 500 watts; at Jackson on 1934 meters at 100 watts; and at Dearborn 1713 meters at 1,000 watts. The transmission is by means of continuous waves and the heterodyne principle is employed for reception. The antenna at Dearborn consists of two five wire aerials of seven strand No. 16 phosphor bronze, supported by three towers 165 feet high and 450 feet apart. More than a ton of copper wire has been sunk in the lake under the antennæ to serve as a counterpoise.

Routine business messages are handled in excess of 400 per day and communication is not interrupted when land wires are down.

A. R. R. L.—Pennsylvania Tests

Extensive tests to determine the availability of the radio telegraph for transmitting railroad messages (other than train orders) in the event of extensive prostration of the wire systems, have been conducted through co-operation between members of the American Radio Relay League, operating under Federal licenses, and the Pennsylvania Railroad System management.

The tests, which covered the principal operating points on the Pennsylvania Railroad System between the Atlantic seaboard on the east, and the Mississippi River on the west, proved in the main highly successful and, in the opinion of the railroad management, demonstrate that the service of the radio telegraph stations embraced in the League offers a practical means of emergency communication.

In the tests which were conducted on the night of May 17-18 under very severe weather conditions (lightning, static, and high winds), a crew of A. R. R. L. stations located along the lines of the Pennsylvania System, delivered correctly 45 out of 50 messages from the four Pennsylvania regional headquarters at Philadelphia, Pittsburgh, Chicago, and St. Louis to the main division points on the system. The messages were all transmitted between 10:30 p. m. and 6:30 a. m. Central Standard time. For full particulars of the tests see Q S T for July, 1924, pages 37, 38 and 39.

(4) Locomotive to Caboose Communication

The Westinghouse Electric and Manufacturing Company has done some development work along the lines of cab to caboose communication, and have designed a 50 watt phone set for the purpose. Loud speakers are used at each end. The sets are quite large and we have no information as to where it is intended to locate them in the locomotive cab or what source of power is used. The development work was done by Westinghouse experts co-operating with the ARA Signal Section, radio committee.

Recommendations:

Your Committee recommends that the Association continue the activities of this Committee and report on developments.

Respectfully submitted,

Committee on the Application of Radio to Moving Trains.

Report of Committee on Power Trucks and Tractors

Insufficient Returns Prevent Compilation of Cost Data Committee Would Like to Present

Committee:—

Louis D. Moore, chairman, electrical engineer, Missouri Pacific R.R. Co.; C. G. Winslow, assistant electrical engineer, Michigan Central R.R. Co.; J. W. Hughes, electrical engineer, Canadian Pacific R.R. Co.; E. W. Jansen, electrical engineer, Illinois Central R. R. Co.; T. F. Foltz, electrical engineer, Washington Terminal Company.

To the Members:—

At the June meeting, in Atlantic City, your committee presented a progress report, and it is with regret that it is at this time unable to amplify that report to any extent.

A questionnaire, copy of which is given, herewith, has been sent to all railroads and terminal companies.

The purpose of this questionnaire is threefold. It will be noted

that the first division of it is really a form to obtain a census of industrial truck equipment in railroad service. The second division is primarily a recommendation as to cost form and cost items to be used in keeping cost records of such equipment. The third division is a repetition of the questions asked at the Atlantic City meeting, which, however, were not discussed at that time, due partly to lack of time for extended discussion.

Replies to these questionnaires are still coming in, but there has not been sufficient time, before report must be in the hands of the Secretary, to properly analyze them. The one outstanding feature of these replies, however, is almost absolute lack of accurate cost records covering operation of this class of equipment. While in a large number of cases the number of men which power equipment will replace is fairly well established, there seems little idea as to what it is actually costing to so replace these men. Many users entirely overlook the overhead and other fixed charges.

This questionnaire was sent to the operating heads of various roads, and it is evident that in many cases the information in the replies was not furnished by the heads of the electrical departments.

INFORMATION

REQUESTED BY COMMITTEE ON POWER TRUCKS AND TRACTORS OF THE ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS

J. A. ANDREUCETTI, Sec'y, Room 413, C. & N. W. Ry. Station, Chicago, Ill.

Date.....Name of Railroad.....

Please give below, the number of trucks of various types which are in use on your lines, together with other information as far as practicable. This does not apply to street trucks, however.

Type of Truck	Class of Service	Commodity Handled	Size and Type of Battery	AVERAGE Weight per Load	AVERAGE Feet of Run	Remarks
Gasoline Tractors						
Trucks						
Electric Tractors—3 wheel						
" —4 wheel						
Trucks—Elevating						
" —Low platform						
" —Baggage						
" —Tiering or stacking						
" —Crane						

Under "Class of Service" show "Freight House," "Shops," "Storeroom," etc. Under "Commodities Handled" show "General Freight," "Castings," "Mail," etc. Under "Battery" shop "Lead" or "Edison" and if possible, size of cells, number, etc. "Weight per load" refers to load per truck for load carrying trucks and per train for tractors. Average run is the feet per trip.

COST

Following is a recommended form for keeping cost data on power trucks and tractors. Which of the items contained therein are used by you in obtaining your cost of operation?

OPERATING COSTS PER ANNUM PER TRUCK OR TRACTOR

Fixed Charges

1. Interest on truck complete @ 6% . . . . . $.....
2. Taxes, license, insurance . . . .
3. Depreciation on truck, less batteries and tires @ 10% .....

Total fixed charges . . . . . $.....

Fig. 1.—Facsimile of Page 1 of the Questionnaire

Maintenance and Supplies

1. Repairs to truck, labor and material . . . . . $.....
2. Battery repairs and renewals . . . .
3. Tire repairs and renewals . . . .
4. Charging current . . . .
   (Total cost including fixed charges up to charging receptacle)
5. Lubricating oil, grease and other supplies . . . .
6. Labor other than repairs, such as charging and watering batteries, cleaning, etc. . . . .
7. Wages of truck operator . . . .

Total charges for maintenance and supplies . . . . . $.....

Total Operating Cost per annum per truck or tractor . . . . . $.....

GENERAL QUESTIONS

As full discussion as possible is desired of the following general questions, particularly as to actual experience with the equipment mentioned.

1. What has been your general experience with use of various types of gasoline equipment compared to electric equipment; (a) in shops, engine-houses and storerooms, (b) in freight house and on docks? Have the fire insurance companies made any difference in premiums because of use of gasoline equipment? Have any fires been caused by such equipment, either directly or indirectly?
2. What has been your experience regarding long trains of trailers behind tractors in freight house work? Cannot freight be handled just as quickly and economically, or even more so, by limiting the length of the train and the weight of the trailing load? What is considered an economical length train in ordinary freight houses?
3. To avoid heavy discharge of batteries, is it the practice to make use of lifts or hauling machinery to help electric trucks over steep grades?
4. Is the effect of cold weather noticeable in the use of either the Edison or lead batteries, particularly as to reduced capacity?
5. Is the expense of equipping electric trucks with ampere hour meters justified? If you use them, for what purpose?
6. Have you ever used overload circuit breakers on electric automotive equipment to protect motors or batteries and with what success?
7. Is the expense of mileage recording devices, such as odometers or speedometers, generally justified?
8. Details entering into cost per kilowatt hour for charging current at the charging plug.
9. General use of crane type electric trucks in roundhouse work. What operations are most usually performed with it? What is the comparative cost with this type equipment, manually operated equipment and overload cranes? Does it require a large house to justify the expenditures for this type of equipment?
10. What are the relative merits of the hand and electric slew and which seems to be generally preferred?
11. Discussion as to merit of worm gear and spur gear drive. Several manufacturers have gone to the spur gear drive, claiming that because of greater efficiency smaller batteries can be used, while others claim they have tried the spur gear and have found it to be noisy and that its average efficiency throughout its life is less than that of the worm gear. What has been the experience with your company?

Fig. 2.—Facsimile of Page 2 of the Questionnaire

For this reason your committee again earnestly solicits a discussion of these questions, particularly of the general questions comprising the third division of the questionnaire.

Your Committee recommends that the committee be continued, with instructions to proceed further with the investigation as outlined in report of 1920, and of such other phases of the matter as the members desire.

Respectfully submitted,
COMMITTEE ON POWER TRUCKS AND TRACTORS.

Report of Committee on Automatic Train Control

Card Records for Inspection, Repairs and Costs Given for Two Roads with Complete Installation

Committee:—

F. E. Starkweather, chairman, electrical engineer, Pere Marquette Railway; E. Wanamaker, electrical engineer, Chicago, Rock Island & Pacific Railroad; G. W. Bebout, electrical engineer, Chesapeake & Ohio Railroad; Charles G. Winslow, assistant electrical engineer, Michigan Central Railroad; J. P. Nelson, supervisor train control, Chesapeake & Ohio Railroad.

TO THE MEMBERS:

Your Committee has held two meetings during the year and arrived at the conclusion that the data and information collected should be offered in the nature of a progress report to date, and accepted as information.

Last year the Committee reported on the various types of automatic train control equipment such as had been offered to the railroads, the exhibits furnishing a description of same. The Committee also made some general recommendations as to the methods of maintaining the automatic train control equipment.

Since the last report was written, some more or less important events have transpired, including a very extended hearing held by the Interstate Commerce Commission at Washington on the subject of automatic train control, with reference to the Commission's various orders that have been issued up to the date of the hearing.

The reports of the hearing have been published in the various railway publications, the Railway Age covering the matter quite fully. In addition, the Signal Section of the A. R. A. have made a historical and descriptive report at their annual meeting, September 23, 24 and 25 of this year. In view of the completeness of this historical record as developed by the Signal Section of the A. R. A., and to obviate duplicating their efforts, it was the decision of the Committee that our Committee report this year should

not go into the matter of historical record, since it is available to all concerned through the reports and proceedings of the Signal Section of the A. R. A. Your Committee wishes to confine its efforts largely to data and information having to do with the main-

Form L. 250

THE CHESAPEAKE AND OHIO RAILWAY COMPANY

MECHANICAL DEPARTMENT

Engineer's Report of Trouble on Engines Equipped with American Automatic Train Control

DATE.....TERMINAL.....ENGINE No.....TRAIN No.....

Condition of equipment:

Right hand contact shoe.....

Left hand contact shoe.....

Electro-pneumatic valve.....

Emergency feature.....

Cab signal.....

Permissive control feature (or slow speed relay).....

Was equipment cut out?.....M. P. or Signal No.....

If so, state why.....

Were any improper stops received in automatic zone?.....If so, show number and color of signal.....

REMARKS:.....

(Sign).....Engineer.

INSTRUCTIONS: This report must be made by engineer in event of any trouble being experienced with automatic train control operation.

Engineer's Report Form on the C. & O.

tenance and operation of such automatic train control as has been actually installed and placed in service.

The Chesapeake & Ohio Railway Company are offering the results of their experiences, based on a year and a half's operation of an automatic train control installation, as made by the American

THE CHESAPEAKE AND OHIO RAILWAY COMPANY Form L. 228 Revised 2-1924

Engine No._____ Month_____ 192____

RECORD OF INSPECTION AND REPAIRS

To AUTOMATIC TRAIN CONTROL EQUIPMENT

Electro-Pneumatic Valve Last Cleaned_____ Batteries Last Applied_____ Electro-Pneumatic Valve Cleaned_____

Date.	INSPECTED AT	TRAIN No. Arrives	TRAIN No. Leaves	Class Insp	Batteries Changed	Number of Battery Applied	Was Equip. Cut in on Arrival	Was Equip. Cut in on Departure	MAINTAINERS NAME
1									
2									
3									
4									
28									
29									
30									
31									

NOTE Show in Inspection Column "T" for Thorough Inspection
"P" for Partial Inspection
Electro-Pneumatic Valve must be cleaned every 30 days and recorded in place provided for cleaning
Remarks should be shown on other side.
This card to be forwarded to the Electrical Engineer, Mechanical Department from first terminal reached after last day in month and new card inserted with last battery change recorded in place provided

Record of Inspection and Repairs—Printed on a Green Card—Actual Size 8½ in. by 11 in.

Automatic Train Control Corporation, the device being of the direct current, intermittent electrical contact ramp type, with 21 miles of track including 57 ramps and 36 locomotives equipped.

The Chicago, Rock Island & Pacific Railroad early in the year completed the installation of Regan Devices Company automatic train control on 165 miles of double track, with 102 locomotives

Form L. 249

THE CHESAPEAKE AND OHIO RAILWAY COMPANY

MECHANICAL DEPARTMENT

Maintainer's Report of Trouble on Engines Equipped with American Automatic Train Control

DATE.....TERMINAL.....ENGINE No.....TRAIN No.....

Was equipment cut out on arrival?.....

Copy here how reported by engineer:

Was equipment cut out?.....M. P. or Signal No.....

If so, state why.....

Were any improper stops received in automatic zone?.....If so, show number and color of signal.....

REMARKS:.....

Engineer's Name.....

Work done by maintainer:.....

(Sign).....Maintainer.

INSTRUCTIONS—This form to be made out by maintainer when trouble is reported by an engineer, or when equipment arrives at terminal cut out. Copy to be sent to Supervisor Train Control.

Chesapeake & Ohio Ry. Maintainer's Report Form

THE CHESAPEAKE AND OHIO RAILWAY COMPANY

AMERICAN AUTOMATIC TRAIN CONTROL EQUIPMENT

ENGINE MAINTENANCE COST 1923 - WASHINGTON-PIEDMONT DISTRICT

MONTH	LABOR	MATERIAL	TOTAL	NUMBER ENGINES EQUIPPED	AVERAGE PER ENGINE
January	$433.61	$ 92.14	$ 525.75	34	$ 15.46
February	492.44	151.46	643.90	35	18.40
March	462.42	261.65	724.07	35	20.69
April	585.75	208.29	794.04	36	22.06
May	607.10	123.31	730.41	36	20.29
June	601.51	263.25	864.76	35	24.07
July	561.95	279.28	841.23	35	25.18
August	601.04	135.19	736.23	34	21.65
September	743.17	220.62	963.79	33	29.02
October	700.94	105.78	806.72	34	23.73
November	710.33	125.80	836.13	33	25.34
December	696.94	130.89	837.83	33	25.09
TOTAL FOR YEAR	7197.20	2097.66	9294.86	413	22.51
1924					
January	$709.16	$ 81.68	$ 790.84	32	24.71
February	611.82	303.12	914.94	35	26.14
March	589.89	743.78	1333.67	36	37.05
April	590.86	528.02	1118.88	33	33.90
May	647.73	542.96	1190.69	32	37.20
June	824.34	322.25	1146.59	31	36.99
TOTAL FOR HALF	3973.80	2521.81	6495.61	199	32.64

NOTE- The increased cost 1924 over that of 1923 is due to improvements and change of freight power.

Train Control Cost Data on the C. & O.

equipped. The Regan Automatic Train Control device is of the direct current, intermittent electrical contact ramp type.

Both the Chesapeake & Ohio and the Chicago, Rock Island & Pacific have offered as exhibits, rules and instructions governing the operation and maintenance of automatic train control, including the forms for making out the necessary reports in connection therewith, which, if found desirable, may be printed in the proceedings.

On the two roads computing data and information to the Committee Report, it has been found that the organization of the maintenance forces is of the utmost importance, and there no doubt will be changes effected in the maintenance organizations as those concerns become more familiar with automatic train control operation. Several months of operation clearly indicates that automatic train control equipment affects or enters into many different phases of railroad operations as a whole.

R. I. **ROCK ISLAND LINES** Form M. P. 114

DAILY INSPECTION REPORT AUTOMATIC TRAIN CONTROL

LOCOMOTIVE EQUIPMENT

Time 12:01 a. m. to 12:00 p. m. Place_____ Date_____

Eng.	Train In		Train Out	Battery	Ind. Selector	Shoe Box	Stop Ramp Buttons	Release Switch	R & B Valve	Speed Controller	Wiring	Conduit	Piping	Condition When Disp.	Cond. Form M. P. 36	REMARKS
	No.	Interruption														

Total Engines Dispatched_____

Roundhouse Foreman must not O. K. a Train Control Equipped Road Engine for service unless Train Control is in operating condition.

SIGNED: R. H. Foreman_____

R. H. Foreman_____

Maintainer_____

Maintainer_____

Daily Inspection Report Form for Locomotive Equipment Used on the Rock Island

FORM M. W. 7. 2-24-5M JJHCo. S. D. 874-C-3.

ROCK ISLAND LINES

INSPECTION REPORT AUTOMATIC TRAIN CONTROL

ROADSIDE APPARATUS MONTH_____ 192__

Date	Signal No.	RAMPS			SIGNAL AT CLEAR			SIGNAL AT CAUTION			SIGNAL AT STOP		Adjustment of Pole Changer	Adjustment of Circuit Controller	Adjustment of Displacement Detector	REMARKS
		Height Above Rail	Gauge	General Condition	Volts on Ramp	Mill. Amps.	Ramp Polarity	Volts on Ramp	Mill. Amps.	Ramp Polarity	Volts on Ramp	Mill. Amps.				

(SIGNATURE)

Inspection Report Form Used on the Chicago, Rock Island & Pacific Ry.

ROCK ISLAND LINES Form MP-115

SEMI-ANNUAL INSPECTION REPORT AUTOMATIC TRAIN CONTROL.

LOCOMOTIVE APPARATUS.

INDICATION SELECTOR								Stick Release Switch		Electro-Magnet			
Motor				Clutch Release		Mechanical Lock							
Drop-Away			Pick-Up			High Speed	Med. Speed						
High Speed		Med. Speed		High Speed		Med. Speed		Pick-up	Drop-away	Release		Pick-up	Drop-away
Volts	Amps.	Volts	Amps.	Volts	Amps.	Volts	Amps.	Amps.	Amps.	Volts	Amps.	Volts	Amps.	Volts	Amps.	Volts	Amps.

Semi-Annual Inspection Report Form for Locomotive Apparatus Used on the Rock Island

The Automatic train control cannot and does not lie within the province of any one department. In fact, it is necessary that the transportation, roadside and mechanical forces and supervisors become entirely familiar with the best method of operation and the best method of maintenance, so that those concerned in the various departments may co-ordinate their efforts to secure successful operation as a whole.

Your Committee has been unable to secure any operating and maintenance data of installations of automatic train control other than the two mentioned, since these two roads are the only ones having completed installations. Therefore, any reference in this report to operating data is of necessity confined to the types above mentioned.

The Interstate Commerce Commission have received reports every month from these two railroads, indicating the performance of the equipment as installed and operated.

The Interstate Commerce Commission have also been supplied with figures on the cost of installation, operation and maintenance, which are available to those interested.

No doubt, as other railroads complete installation of automatic train control, they will be able to offer to the Committee exhibits which will thoroughly explain the method of operation and maintenance of their systems of automatic train control as installed upon their individual lines, and it is the recommendation of your Committee that a Train Control Committee be continued in order that it may collect and analyze this data and information as it becomes available from the various lines, so that eventually the proceedings will clearly indicate the types of equipment and the method of maintenance and operation used by the individual lines, thereby becoming a source of information to all those interested in developing or improving their methods of operation and maintenance of the various types of equipment such as may be in use on the different railroads who have been requested by the Commission to install automatic train control.

The importance of design and installation of the locomotive equipment of an automatic train control system in such a manner that it will function satisfactorily under the conditions which will necessarily affect it, due to weather exposure, temperature changes, vibration and shock, all of which are incident to locomotive operation, is obvious.

It is the hope of the Committee that the discussion on the floor will be thorough and complete, especially with reference to all the various parts of automatic train control equipment, as applied to locomotives.

Respectfully submitted,

COMMITTEE ON AUTOMATIC TRAIN CONTROL.

Report of Committee on Stationary Power Plants

Certain Accessories Will Show What Plant Is Doing and Make Possible More Economical Operation

Committee:—

C. G. Winslow, chairman, assistant electrical engineer, Michigan Central Railroad; Frank Lane, electrical engineer, Wabash Railroad; T. F. Foltz, electrical engineer, Washington Terminal Company.

TO THE MEMBERS:

Your Committee on Power Stations presents a few notes with the idea of setting you to thinking constructively rather than of giving you instruction.

The American Railway Association Committee on Modernization of Stationary Boiler Plants has developed an excellent report (1922 Proceedings, page 387), valuable for reference when designing a small power plant. This report touches on chain grate stokers, relative cost of steel, brick and concrete stacks for power station of 150 to 600 boiler horsepower, welding of steam pipes, steam economy of various types of prime movers for stationary power plants and settings for return tubular boilers. You are urged to read this report carefully, always keeping in mind that many schemes and devices which are suitable and economical for a 1,000-hp. plant are not so for a 200-hp. plant.

The curves showing annual maintenance and depreciation cost for steel, brick and concrete stacks should be carried a step farther and made to include investment charges. This will show the steel stack to be suitable and economical for a somewhat larger plant, say, 250 hp. instead of 150 hp. and the brick or concrete stack suitable for all larger plants.

Your Committee's report will be confined to two subjects, i.e., boiler instruments and feed-water regulators.

The intangible nature of savings in the boiler room, in the process of converting the heat of coal into usable energy, often leads those unfamiliar with the details into distrust. In order to have conclusive arguments, it is therefore necessary first to measure the input in pounds and quality of coal, and second to measure the output in terms of water evaporated. The size of plant and amount of power produced will determine the amount of money which may be economically invested. No more should be spent on accessories than can be saved by reason of having them. Each case must be figured out for its own condition, taking into consideration the necessity for continuous service and the skill of attendants available. Take, for example, a plant burning 15 tons of coal per day for 200 days, or 3,000 tons at $4.50 per ton, equal to $13,500 per year. If a 5 per cent saving can be effected, or $675 per year, it should be proper to spend $2,000 on devices to measure input and output.

Input can be measured roughly by weighing coal in the car.

Output can be measured by an integrating and indicating steam flow meter to which must be added an estimated amount to account for loss of heat in blowing off the boilers. Output may also be found by measuring the feed water by an orifice meter to which must be added the estimated loss from blow-off.

In a large plant the blow-off water may be measured by an orifice meter.

In order to check plant operation from day to day and to guide the fireman in obtaining complete combustion without admitting too much air, some simple device should be provided for learning the percentage of CO_2 in the flue gas, also temperature of the flue gas entering the stack. Care should be taken not to attempt using CO_2 recorders of too complicated nature, because the average engineer or fireman will not understand it, and will become discouraged in trying to keep it operating. A simple device for continually drawing into it a small amount of flue gas for 8 hours consists of a tank holding about 20 gallons of water with a gas connection into the boiler breeching. The water may be allowed to drip slowly from the tank, thereby drawing into it a tank full of gas in 8 hours. This gas will be an 8-hour sample, which may be tested by a portable hand set at the end of the 8-hour shift. The test will indicate the average percentage of CO_2 for 8 hours obtained by the fireman on duty for that shift.

High percentage of CO_2 does not tell the whole story, and we must also know the temperature of flue gas going into the stack. Good boiler operation calls for a high percentage of CO_2 and low temperature of flue gas.

Two simple draft gages will be found useful for indicating holes in the fire and to show whether soot or slag has gathered on the tubes. One gage should be connected between atmosphere and the space above the fire. The other gage between the space above the fire and the last pass. A comparison of the two gages will after a little practice give the fireman much valuable information about his fire that he cannot otherwise know.

Where uniform steam pressure is necessary, a feed-water regulator which will increase the flow of water into the boiler immediately after the level of water in the boiler begins to fall, will give a much more uniform flow of feed water than if regulated by hand. This will have the effect of more uniform steam pressure. With hand regulation at times large quantities of water are admitted to the boiler with consequent cooling and reduction of steam pressure.

All of the above remarks should be taken as applying to plants of the order of 1,000-hp. output and may not be true for large steam plants.

Respectfully submitted,

COMMITTEE ON STATIONARY POWER PLANTS.

Report of Committee on Self-Propelled Cars

A Resume of Equipment in Operation Today, Pointing Out the Probable Lines of Development

Committee:—

R. G. Gage, chairman, electrical engineer, Canadian National Railways; E. Wanamaker, electrical engineer, C. R. I. & P. Railroad; L. L. King, electrical engineer, A. T. & S. F. Railroad; E. S. Macnab, engineer car lighting, C. P. Railway.

To the Members:

Your committee is pleased to submit its report on Self-Propelled Rail Cars.

A very satisfactory meeting, at which all but one of the committee were present, was held in Montreal during August. There has also been considerable correspondence and several personal discussions between the individual members in regard to the committee work.

In the general consideration of the subject of self-propelled rail cars, your committee feels that the design is not sufficiently standardized, at the present time, to attempt a detailed analysis of the different cars or to try and establish actual operating costs. As mentioned in our progress report at the June meeting, we believe that no radical change has taken place in these cars since this committee made its annual report last year, and our effort is merely to touch upon the high points of the art, and indicate the probable lines of development.

The problem of transportation on the branch lines and for local service on main lines of steam railways is becoming more acute each year, and is receiving more attention by the railways generally. A recent check of the traffic conditions on some of the South Western Lines has indicated a loss or falling off in local traffic of approximately 80 per cent. All the railways are interested in a unit car, of a type which will best stand the severe railway service, and which will be ready for service when required, and which, of course, will operate at a reasonable cost. The actual operating cost per car mile is perhaps the least important, for the reason that almost any car that will fit the scheduled requirements, can be operated more economically than the steam train, which it replaces, and although the car does not actually earn money, it will reduce the operating losses.

In the general consideration of the subject of rail cars, it appears that the present types of storage battery motor drive, or gasoline mechanical drive, are not without serious limitations. The chief objections to the storage battery car are the low efficiency of the battery itself, and the limitations in operating time, due to the necessary battery charging period, a part of which occurs in the most profitable earning period of the day. The car operates very satisfactorily for medium speed runs, and is reliable to a very great degree when given ordinary intelligent maintenance. It not only reduces the cost of operation as compared with steam trains, but in many cases shows an actual earning, after taking all interest and depreciation charges into account, both on the car and on the charging equipments.

Criticism of the gasoline mechanical drive in the past has been that sufficient attention has not been given to the design of the engine for the high speed service in which it was placed; in other words, it is recognized now that the gasoline engine that is to be run at high speeds must be designed particularly for that service, if a reasonable life is to be expected. Difficulty has also been experienced in absorbing the track shocks which are inherent in rail operation, and of keeping them from being carried into the transmission and to the engine. The standard method of speed change through shifting gears is quite noiseless and smooth when properly operated, but can be noisy and objectionably rough when carelessly operated. However, the Sykes Company have recently built a two-car motor train, using a Sterling high speed motor with a transfer gear transmission. This type of construction well deserves study and investigation. The Mack Company also are building a motor car, with the power unit built into the truck, with one or both trucks of the car so equipped, utilizing electro-pneumatic multiple unit control. This type of equipment, in view of what it may have to offer, also deserves study and investigation. In the electrical field the Electromotive Engineering Company have just completed a car utilizing a Winton Marine type engine, with electric generator and motor transmission, the whole operated by means of a simple and sturdy control, which well deserves careful study and investigation.

There seems to be a tendency, both on this Continent and in Europe towards the development of a car, using an oil electric generator set and motor drive generally of this type. There are examples of this type of equipment in England, Sweden, Switzerland and the United States, all of which are in a general way similar, although varying in details of design and materially in the weight of the power plant. By means of the electric drive, the output of the engine and generator can be utilized almost entirely as torque when it is required, or gradually converted into speed, these changes being gradual and unobjectionable. Examples of this construction are the Diesel-Electric locomotive of the Ingersoll-Rand-General Electric, now in operation on the New York Central Railroad in New York, also the gas electric cars recently built in St. Louis by the Electromotive Company.

As an addition to the oil electric car, there is a design including a storage battery, which operates in parallel with the generator and delivers power at the peak load periods of maximum grade or acceleration. The reciprocal condition theoretically exists, that when running down hill or on the level when requiring less than the output of the generator, the additional generator power is available for charging the battery, thus tending to keep a uniform load on the engine.

This idea is not new and is being tried out at the present time in a road bus in New York City. The idea has also been tried out in several types of automobiles, and in other forms of industrial equipment. A careful study of this feature of oil electric battery car is being made at the present time by the Canadian National Railways, and it will be very interesting to see how the car, if built, actually works out.

It is the committee's opinion that it will be found, as in other applications, except in special cases, that the advantages which exist theoretically in the use of an auxiliary battery for propulsion, will not be sufficiently great to offset the additional cost of maintenance of the battery and the complications of control made necessary by its use.

The Canadian National Railways now have eleven storage battery cars in operation on runs varying from 8 to 90 miles. The average weight of these cars is 34.5 tons and the battery energy consumption is 40 watt hours per ton mile. This gives a theoretical cruising radius of about 100 miles, as the battery has a rated capacity of 135 kilowatt hours, but in actual practice, in order to overcome bad rail conditions, adverse winds, etc., we have found that it is not satisfactory to attempt to operate more than about 95 miles on a charge.

Besides the storage battery cars, this railway has in operation eight gasoline cars varying in weight from 9 tons, with 33 seating capacity to 33 tons and 58 seating capacity. One of these cars has about 80,000 miles to its credit, within about 2½ years, after which it is undergoing a complete general overhaul. The gasoline consumption per car mile varies from 3 to 12 miles per gallon, depending on the size of equipment and character of run. With the exception of the smallest types, these are all operated with a two-man crew. The cost of operation per car mile for these gasoline cars, exclusive of capital charges, varies from 11c to 50c, and for the storage battery cars, also without capital charges, varies from 15c to 80c, depending upon the cost of power and the season of the year. Besides the actual operating cost of the storage battery cars, there are the interest and depreciation charges on the terminal charging equipments, the capital cost of which, in many cases, represents about $10,000.00, as in the majority of the runs, a charging set is required at each end, and in many cases can be used for nothing but the battery charging. Wherever car lighting batteries can be charged a combination set is used, suitable for both purposes.

In reply to one of the questions asked at the Atlantic City meeting in June, we wish to say that the subject of road buses as competitors or feeders to the railway has been given consideration and study, and that it has been found that there is considerable activity in this mode of transportation, both in freight and pas-

senger service. In some parts of the United States, particularly in the east, road freight service is a very active and important competitor to the steam railways, and it is the committee's opinion, that it will be necessary for the railways and the bus lines to come together on a more equitable basis than at present, as the road transportation companies are enjoying exemption from capital and maintenance of way charges to such an extent as to produce unfair competition.

It is a very strong probability, that the road buses will act in co-operation with the steam railways and establish a service, which will in many cases permit the railway to abandon branch line service, at least until such time as the bus has produced additional traffic to warrant the steam roads operating at a profit.

The problem of road service is closely allied with that of the steam railway branch line operation, both in the methods of operation as well as the design of the equipment. Most of the leading truck and bus designers are endeavoring to apply their equipment to the rail car. Both bus and rail cars are designed, and are being tried out at the present time embodying the straight gasoline mechanical drive, the gasoline-electric, and the gasoline-electric storage-battery types. The gasoline-electric buses in city and interburban service are being introduced, the claims for this type being considerably lower operating and maintenance cost, as well as greatly superior riding qualities, due to the elimination of mechanical shock during speed change periods, and also a decided increase in the rate and uniformity of acceleration.

In making a study of rail car equipment, it should be carefully borne in mind that reliability of service is a requisite of the greatest importance.

Second,—That the equipment in a car must be easily accessible at all times, and must be capable of economical maintenance. In this connection the equipment should be so designed that a car can be placed in service, and continue on its run satisfactorily, until such time as it has completed its allotted mileage similarly to allotted locomotive mileage.

Third,—That the total operating costs, including fixed charges must be given due consideration in order that these fixed charges shall not prove to be excessive, especially as automotive equipment does not have the long life attributed to steam.

Last,—but not least, if automotive equipment is to be successfully operated on steam railways, an organization must be created, which will give it the attention equivalent to that which is now enjoyed by the steam locomotive.

Recommendations

The committee recommends that the study of this important problem be continued and progress and development reported upon.

Respectfully submitted,

COMMITTEE ON SELF PROPELLED CARS.

Report of Committee on Electrical Storekeeping

Answers to Questionnaire Shows a Wide Variation in the Handling of Stocks of Electrical Material

Committee:—

Edward Wray, chairman, Railway Purchases and Stores; R. A. Dean, inspector, Pullman Company; G. B. Colegrove, chief electrician, Illinois Central Railroad; R. C. Raether, electrician, Michigan Central Railroad; H. C. Geimer, electrician, storekeeper, C. & N. W. Railroad; H. A. French, electrical foreman, A. T. & S. Fe Railroad.

TO THE MEMBERS:

As a basis for this committee report a questionnaire was sent to all electrical engineers, chief electricians, superintendents of telegraph, signal engineers and general storekeepers of all railroads over 300 miles in length. Answers were received from 70 railroads operating approximately 237,550 miles in the United States and Canada.

The answers received contain replies from 35 electrical engineers and chief electricians, 33 superintendents of telegraph, 33 signal engineers and 40 general storekeepers.

QUESTIONNAIRE ON ELECTRICAL STOREKEEPING METHODS

Storing Electrical, Signal and Telegraph Materials

Railroad:—

1. Are your stocks of electrical material for the electrical, signal and telegraph departments stored separately from mechanical department stocks?
2. Do you maintain a special electrical section at the general storehouse?
3. What official has supervision over ordering stocks of:
   (a) electric car lighting material,
   (b) headlight material,
   (c) signal material,
   (d) shop and terminal light and power material,
   (e) electrical construction material,
   (f) telegraph material.
4. Do you maintain sub-stocks at local points of:
   (a) electric car lighting material,
   (b) headlight material,
   (c) signal material,
   (d) shop and terminal light and power material,
   (e) electrical construction material,
   (f) telegraph material.
5. Is this sub-stock material charged off stores records when received in sub-stock?
6. Is it included in the annual inventory of stock?
7. Is the master stock book system employed in keeping electrical stock records?
   (a) If not, what system of records do you employ for each of the stocks? (Please send forms.)
   (b) Is the classification of this material in accordance with the A. R. A. Div. VI material classification?
8. Assuming that the stores department could get full co-operation from the electrical, signal and telegraph departments, what would be your recommendation as to the best method of handling electrical, signal and telegraph material stocks?
9. If you have what you consider good facilities for your elec-

Northern Pacific Method of Handling Electrical Materials—Electrical Section in General Storehouse

trical stores won't you kindly send a description with plans, sketch or photos of the layout?

* * * * * * * * *

The above questionnaire was sent to general storekeepers and electrical engineers. The questionnaires that went to the signal engineers and the superintendents of telegraph were different in

Union Pacific System Method of Storing Electrical Materials in General Storehouse

questions 3 and 4 in that they related therein only to the materials in which they were interested.

In the report on telegraph material, 17 roads with approximately 21 per cent of the total mileage, stated that the Western Union handled all telegraph material and the railroad obtained it directly from that company as needed. The Western Union in turn invoiced the railroad for the amount used. Therefore, in the balance

Another View in Electrical Storeroom of Southern Pacific

of this report these railroads are eliminated from the conclusions as to telegraph material.

As was to be expected, there is only a slight variation in the answers to the first two questions. Sixty roads with approximately 85 per cent of the total mileage represented, showed that their electrical signal and telegraph stocks were stored separately from the mechanical department stocks, the remainder reported that they had no separate facilities for their electrical stock.

In answer to the 2nd question 61 roads, or 90 per cent of the mileage, reported that they did have separate electrical sections in the general storehouse, the remainder of the roads did not. The summary of the answers to these two questions for each road were based, to a great extent, on the answers to the questionnaire as sent in by the general storekeeper, as there seemed to be some confusion in the minds of the other departments as to what was meant by the storing of electrical material separately and as to the maintenance of a special electrical section in a general storehouse.

The answers to question 3, "What official has superivsion over the ordering of electrical stocks," showed that 23 railroads with 35 per cent of the mileage gave this work to the stores department in co-operation with the heads of the department interested for all classes of electrical stocks, and on nine roads with seven per cent of the mileage, the using department handled all its own material. The remaining 38 roads with 58 per cent of the mileage left the ordering of electrical stocks to the general storekeeper to be handled the same way as any other material.

In the carrying of sub-stocks, 13 railroads with 16 per cent of the mileage, stated that they carried no sub-stock of electric car lighting material; seven roads with ten per cent of the mileage carried no sub-stocks of headlight material; 20 roads with 34 per cent of the mileage carried none of signal material and 20 roads with 41 per cent of the mileage reported they carried no sub-stocks of telegraph material. In addition to these there were five roads

Electrical Section in Southern Pacific Storeroom

with nine per cent of the mileage that reported as carrying no sub-stocks whatever, but these with only a couple of exceptions were roads of under a thousand miles in length or were roads partially electrified where local storehouses took care of their electrical needs. Those reporting no sub-stocks of signal material did not have signal facilities large enough to require sub-stocks and for shop terminal lighting and electrical construction material requisition was made directly on the storehouse.

There were some variations in the answers to questions 5 and 6 regarding the charging out of sub-stocks and these questions are handled together because of their close relationship. Where a report of one of the using department superintendents varied from that of the general storekeeper's report, the answer of the stores department man was taken as correct. Only three out of nine roads that charged sub-stock material off stores department books when received in sub-stock, were over a thousand miles in length. The remaining 60 roads did not charge out this material in sub-stock until it was actually used. Two roads of under a thousand miles in length do not include their charged out sub-stock in their annual inventory.

In reply to question 7 (a) and (b) relative to master stock book, 13 railroads did not answer the question. Forty-three roads, representing 64 per cent of the mileage, use the master stock book in keeping track of electrical material. The remaining 14 roads

with 28 per cent of the mileage do not use master stock book because other methods of stock keeping are employed.

The answers to question 8, asking for recommendation as to the best method of handling electrical, signal and telegraph material stock varied considerably. Only 54 of the 70 roads answered this question. Ten of these, representing 25 per cent of the mileage, stated that their present methods of handling electrical materials, wherein the stores department handles them in separate section but the same as any mechanical stock, were entirely satisfactory. Of these ten, three electrical engineers recommended this practice. Only five heads of electrical or signal departments recommended that their electrical stock be placed immediately under their jurisdiction and handled entirely by them. The general opinion of the remainder answering this question, but who are using at present different methods, was that electrical material should be handled by the stores department the same as any other material. Those answering this question in this manner recommended that the man handling electrical material for each department be thoroughly schooled in the use of the material under his care and be, if possible, a man taken directly from the department where the material is used. They further recommended that he be under the jurisdiction of the general storekeeper.

There were only 13 answers to question 9 as to present facilities for handling electrical material, two of which reported their facilities good, three fair and the rest that theirs were very poor. Four others stated that improvements were being made on their line at the present time but to date had not been completed.

* * * * * * * * * *

The accompanying photographs show how the electrical stocks are stored on railroads which provide separate sections for this class of material.

Conclusion

The answers to the questionnaire showed that there is a wide variation in the methods of handling stocks of electrical material on American steam railways. The prevailing method is to allow the stores department to handle these materials the same as mechanical stock.

It is the recommendation of this committee that:

(a) The stores department should handle all electrical materials.

(b) The stores department should have a separate section for storing these materials to segregate them from mechanical stocks.

(c) The man in charge of the electrical section should be one well acquainted with the material and the usage to which it is put, and where possible he should be taken from one of the departments using that material.

Respectfully submitted,

COMMITTEE ON ELECTRICAL STOREKEEPING.

Report of Committee on Train Lighting Equipment and Practice

Tendency Appears to Be Towards Deeper Battery Boxes With Longer Periods Between Cleanings

Committee:—

Ernest Lunn, chairman, electrical engineer, Pullman Company; L. S. Billau, assistant electrical engineer, Baltimore & Ohio Railroad; F. J. Hill, chief electrician, Michigan Central Railroad; D. J. Cartwright, electrical engineer, Lehigh Valley Railroad; J. L. Minick, assistant engineer, Pennsylvania System; A. E. Voigt, car lighting engineer, Atchison, Topeka & Santa Fe Railroad; J. J. Hack, engineer train lighting, heating and ventilation, Southern Pacific Railway; E. S. M. Macnab, engineer of car lighting, Canadian Pacific Railroad; A. E. Ganzert, electrical supervisor, Chicago, Rock Island & Pacific Railroad; R. E. Gallagher, assistant electrical engineer, Louisville & Nashville Railroad.

TO THE MEMBERS:

Axle Pulleys

The axle pulley question claims the attention of association members interested in axle generator operation and belt maintenance. In last year's report reference was made to pulleys of two lengths, 33½ in. and 28½ in. Further experience has shown that the shorter pulley is preferable on account of clearance requirements for proper application, and that the reduced length of face does not materially, if at all, lessen its effectiveness in reducing belt losses. Belt mileage with the 28½-in. pulley is considerably higher than with the 10 in., especially on railroads having many short radius curves, particularly in yards. On roads having few or no sharp curves the advantage is not so pronounced. This question, including that of axle pulley bushings, is not settled, although marked improvement has been recently made in design and workmanship. Generator pulley size has a decided bearing on belt life; as a rule, pulleys of large diameter give the best results. The corrugated bushing which has been standard for a number of years has become the subject of criticism, especially when used with two hub pulleys where the usual method of clamping does not produce the same initial tightness that can be obtained with a single hub off center mounted pulley. This subject is worthy of thorough investigation, with a view of developing a standard unit which will meet demands for simplicity of construction, ease of application and remain permanently in place when properly fastened.

Axle Generators

There have been no developments of particular moment during the past year in generating and regulating equipment. Manufacturers are endeavoring to firmly establish their own standards, based on satisfactory service consistent with production costs. The assurance that car lighting equipment of today will render service subject to less criticism than ever before is gratifying to purchasers and speaks well for the engineering effort put forth by designers in their endeavor to produce the best. The same may be said of the makers of electrical accessories necessary for properly equipping a railroad car. But for the hand in hand cooperation of the manufacturers and users progress would have been retarded, and instead of the well lighted cars of today, the traveling public would be undoubtedly inconvenienced as a result of insufficient and poorly arranged illuminants.

Suburban Coach Lighting

The question of suburban coach lighting has not been definitely answered. Local conditions prohibit a single standard applicable to all cases. There are examples of axle generator lighting with battery auxiliary in which the service, so far as the public is concerned, is all that could be desired. The same may be said of the number of installations in which a turbo-generator mounted on the locomotive supplies the necessary energy either with or without battery protection. Needless to say this phase of car lighting has not been given the serious consideration that trunk line equipment has received, but it is due to be much in evidence from now until it stands as well developed as the latter and that in a relatively short time.

Where axle generators are employed the question of size of dynamo and cut-in speed, as well as kind of regulation, are important factors. The type and capacity of the storage battery must also be considered. With the turbo-generator combination a careful study should be made to establish the proper relationship between the size of generating unit and number of cars to be lighted, also to determine to what degree the service must be protected by storage batteries. Obviously no general rule can be laid down by your committee, but it is the purpose to keep in touch with developments in the art and, so far as possible, with the requirements of service in order that examples of most advanced practice may be available for study with profit to those interested either in new propositions or in the revamping of old.

Battery

The tendency among railroads to increase car shopping period has brought about a condition in battery maintenance practice which can only be met in most cases by a change in tank and crate dimensions, necessitating an increase in height of battery box.

It is highly desirable, if maximum life of positive elements is to be obtained, that the battery remain undisturbed on a car from the time it goes into service until the car is shopped. This cannot be done, where the service is severe, unless there is sufficient space underneath the plates to hold all of the sediment which may be deposited without its touching and short circuiting the plates.

As a result of extended experiments and observation on a large number of batteries some of the railroads have adopted a cell having a 3-in. high plate support in place of one of 1¾-in. Service results have shown that the move was well advised, as a decided saving is made possible by this improvement. It is reported that batteries can be kept in continuous service for a period

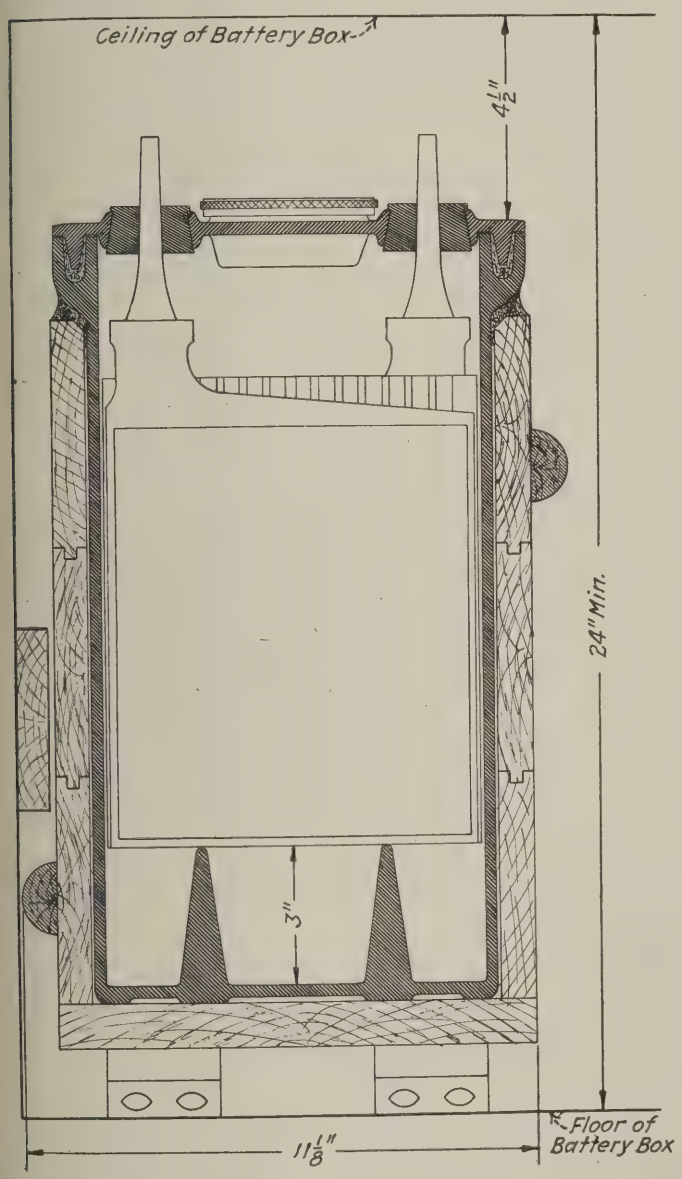


Fig. 1 Sectional View of Battery Showing Clearances

approximately 100% longer than formerly at considerably less maintenance cost as the first dismantling usually comes at about the time the second cleaning is necessary with the old type. The labor cost of one cleaning of a lead battery alone with consequent damage to plates, separators, tanks, and crates is sufficient, when saved, to go far in offsetting the cost of making the change which will result in a decided saving in subsequent plate renewals and cleanings.

Another factor to be considered is that of increasing the depth of the electrolyte space above the tops of the plates with a view of lengthening the flushing periods and bring about a saving in labor. A third change from present standard practice is to provide from four and a half to five and one-half inches of free space between the top of the battery and the ceiling of the battery box in order that the cells may be flushed without making removal of the trays from the battery box necessary. In installations of this kind the trays are not moved from their position after having been securely fastened in place from the time the car leaves the shop until it is returned possibly for two to four years later. A noted saving, therefore, results from a reduction in labor required for handling and in lessened damage to crates, cells and connectors.

To accommodate the deeper battery cells a battery box having a free inside height of not less than 24 in. should be provided. Fig. 1 shows a typical arrangement standard on one railroad and is published only as information.

The increased space provided facilitates the care of Edison batteries as well as lead, as the "high wide" cells can be maintained to advantage as their removal for flushing is made unnecessary.

The following changes in standard battery box dimensions, as adopted by both this association and by the American Railway Association are, therefore, recommended:

Height in clear, from 21½ in. to not less than 24 in.

Depth, front to back, from 25 in. to not less than 31 in.

Length of compartment to hold two standard double compartment trays, from 22⅝ in. to 23⅝ in.

Length of compartment to hold four standard double compartment trays, from 3 ft. 9½ in. to 3 ft. 11½ in.

It is further recommended that where a change to the deeper type of lead battery cell is made that the following tray dimensions be adhered to:

Maximum length over all, 28½ in.

Maximum width, 11⅛ in.

Length of compartment to hold four standard double compartment trays, from 3 ft. 9½ in. to 3 ft. 11½ in.

Battery Trays

The question of impregnating wooden battery crates has been given consideration, and earlier prediction that the paraffine treatment, if properly given, will greatly prolong the life of the wood and make crate renewal less frequent appears to be well founded. In order that railroads that have not already taken steps to install the paraffining tanks may be advised as to what has proven to give the best results the following detail method of procedure is presented:

1. Immerse the wood crate complete, with hardware and porcelain parts attached, in a tank of paraffine kept at a temperature of from 240° to 250° F. for from forty-five minutes to one hour, or until bubbling has stopped, indicating that moisture in the wood has been converted to steam and driven off.

2. Remove the crate from the super-hot paraffine and immediately immerse it in a tank of the same material kept at a temperature of from 140° to 160° F. for from ten to twenty minutes, or until the wood of the crates has had time to cool throughout to the temperature of the wax. It is essential that this be done as well as that the temperature of the second tank be kept down to about 150°, otherwise the impregnation will be incomplete and there will be little evidence of paraffine on the surface of the wood.

3. If after the crate has been removed from the second tank and allowed to cool, there does not appear to be sufficient wax on the surface of the wood to make a perceptible coating, it should be dipped again for only a moment in the cool tank.

Hard Rubber Battery Jars

It has been found that in general, where hard rubber battery jars are used, those made of high grade material give enough better results to warrant their relatively high cost due to reduced breakage in service. Covers should be made of the same stock as the jars. A considerable variation in tensile strength and elongation characteristics is permissible. Jars of material which show 7000 lb. tensile strength and a 6% elongation at 70° F. show about the same lasting qualities as those of 3000 lb. tensile and a 22% elongation. Extreme brittleness with low ductility should be avoided.

Rubber jars should be securely set in solid wooden crates without the use of asphaltum or other compounds for holding the tanks in place except to seal the jar and crate together at the top, as shown in Fig. 1. The compound used should have a relatively high melting temperature (preferably not less than 225° F.). This precaution is necessary in order that it will not soften and pull away from the jar during hot weather. To prevent the compound from running down between the jar and the crate a small amount of asbestos rope or wool impregnated in compound and

used as a filler will be found effective. For the cover grooves compound which pours at about 76° F. should be used.

Krebb Pulley

Last year's report referred to the service obtained from the use of a universal axle pulley. It is reported that a few additional cars are being equipped with this device for extended observation.

The use of chain driven generator for particularly severe service conditions is also being watched.

Train Lighting Lamps

During the past year or two there has been an increased demand for the 25 and 100 watt gas filled train lighting lamps in the 30-34 volt range. The manufacturers have generally been furnishing the 25 watt lamp in PS-16 bulb. One or more roads are using this lamp in PS-18 bulb. The total demand for 25 watt lamps is, however, relatively small when compared with the other sizes now in common use. The 100 watt lamp is furnished regularly in the PS-26 bulb and although, as stated above, there has been an increase in the use of this lamp, the total volume of 100 watt lamps used is relatively small.

In view of the demand for two sizes of bulb in the case of the 25 watt lamp, and of the relatively limited demand for both the 25 and 100 watt lamps, the committee recommends that the adoption of either of these lamps as recommended practice be withheld for at least another year or until more definite information may be secured as to the trend of the art.

Respectfully submitted,

COMMITTEE ON TRAIN LIGHTING EQUIPMENT AND PRACTICE.

Report of Committee on Starters and Controllers

Essential Features Which Committee Believes Should Be Incorporated in Well Designed Equipment

Committee:—

G. W. Bebout, chairman, electrical engineer, Chesapeake & Ohio Railroad; L. L. King, electrical engineer, Atchison, Topeka & Santa Fe Railway; J. E. Gardner, electrical engineer, Chicago, Burlington & Quincy Railroad; G. T. Goddard, general electrical foreman, Illinois Central Railroad; F. W. Reed, chief electrician, Northern Pacific Railroad.

TO THE MEMBERS:

General

1. In this report your Committee recommends to the railroads the essential features that should be incorporated in all well designed starters and controllers but has not undertaken to draft specifications for the manufacture of equipment of this character.

2. In view of the abuse and damage to controls and motors in the hands of ignorant or careless operators where manual control is used, we recommend push button automatic controls be used wherever applicable to the operation. While the cost may be slightly higher, the greatly reduced maintenance cost and the saving in lost time of the machinery by the use of the automatic control, will more than offset any difference in cost of the control apparatus.

3. (a) We recommend all starters be protected by circuit breakers or overload relay protection or its equivalent in preference to fuses, for the better protection of the equipment and to reduce the cost of protection, as fuses are an item of considerable cost to railroads and the danger of over fusing results in many motors and controls being damaged.

(b) Although it is permissible to operate small a.c. motors up to 5 hp. with a double throw starting switch fused on the running side, and in some localities larger motors are permitted to be thrown on the line with a single throw switch, we do not recommend the use of knife switch and fuses for across-the-line type of starting methods, as it results in a large number of burned out motors and considerable loss to the railroads. Overload relays or circuit breakers when properly set will protect the motor against overload due to single phasing.

General Specifications

GENERAL PURPOSE WITH DEFINITIONS—ELECTRIC POWER CLUB DEFINITIONS USED THROUGHOUT

4. All electric motor controls used in railway service are to be dust proof, splash proof or weather proof as specified by the purchaser.

(a) "Dust proof apparatus is so constructed or protected that the accumulation of dust will not interfere with its successful operation." EPC 1003.

(b) "Splash proof apparatus is so constructed as to be protected against the entrance of a spray of water from any direction." EPC 1008.

(c) "Weather proof apparatus is so constructed or protected that it will not be injured if exposed to the weather." EPC 1010.

5. (a) Sufficient space must be provided in the controller or cabinet for the admission of all wiring. For wire of No. 4 B & S gage and larger there must be sufficient space to reach the terminals with standard stranded D. B. R. C. conductors without making short right angle bends.

(b) Wiring diagrams to be furnished with all controls, preferably posted inside the cover or door. Each terminal for external connection to be plainly and permanently marked.

6. (a) All inspection covers of enclosures to be equipped with fasteners to hold them securely, yet to be easily opened by the use of ordinary pocket tools.

(b) Starters and controllers with exposed live parts must be enclosed in cabinets. Cabinets must be provided with doors so arranged that only authorized persons can have access to the controller.

(c) Motor starting rheostats should have enclosures with handles for external operation.

7. (a) All wearing parts to be accessible and easily replaced without sending to shops. Where contact fingers are used for currents of various values, for handling the heavier currents two or more contacts of the same size as the others are preferable to a single contact of a larger size. This will reduce the number of items to be carried in stock for repairs.

(b) Also the contour of the fingers and tips be such that close adjustment is not necessary to prevent the fingers from stubbing or bending when the drum or arm is turned in either direction.

(c) All segments to be removable, with screws in countersunk holes of sufficient depth to protect the heads, screws to be located far enough from the ends of segments to prevent arcs burning the screws.

8. On controls for motors up to 50 hp. used for machine tools and other drives that start free of load, the field relay may be omitted when the speed range is not greater than 2 to 1, except for wheel lathes, etc., which require special controllers having slowdown and accelerating features. This will enable the same controller to be used for both constant speed and adjustable speed motors, by having field rheostats for the adjustable speed motors.

9. Use Power Club Service Classification of resistors (EPC 8703) for standards, specifying one of the following:

Light starting duty.
Heavy starting duty.
Light intermittent starting duty.
Heavy intermittent starting duty.
Continuous duty.

10. Follow Power Club definitions for low voltage protection, low voltage release, and overload protection.

(a) "Low voltage protection is the effect of a device operative on the reduction or failure of voltage to cause and maintain the interruption of power to the main circuit." EPC 1506.

(b) "Low voltage release is the effect of a device, operative on the reduction or failure of voltage, to cause the interruption of power to the main circuit but not to prevent the re-establishment of the main circuit on return of voltage." EPC 1507.

(c) "An overload protection is the effect secured by a device, operative on excessive current, to cause and maintain the interrup-

tion of current flow to the device governed. When it is a function of a controller for an electric motor the device employed shall provide for interrupting any operating overloads, but may not rupture short circuits." EPC 1520.

11. All starters and controllers to be tested at the factory under as near operating conditions as possible, and properly adjusted before shipment.

Control for Machine Tools

12. Specifications for general purpose motors to apply to controls for machine tools, with provision for special features, as required.

13. For wheel lathe operation, direct current motor controls should be push button automatic for adjustable speed, slow-down, and accelerating, with overload and low voltage protection; also field rheostat relay for short-circuiting the field resistance when starting, as this type of machine must frequently be started with load that would cause damage to the motor if started on weak field.

(b) Where a.c. motors must be used on wheel lathes, the control should be equipped with a contactor remaining closed normally to cut out the starting resistance, with a push button for opening the contactor to insert the resistance to give 50 per cent speed reduction for hard spots on tires. This will save the expense of change gear speed box, which is not necessary where proper speed of 13 to 14 ft. per minute is provided in original gearing.

14. D. C. controls for shapers, crank planers, and such other machines as are not equipped with braking devices, should be equipped with dynamic braking feature, to save time, and increase the output of such machines.

Control for Turntables

15. (a) For turntables having two motors, the controller should be of the duplex type, having both motors operated from one controller.

(b) The control should be equipped with protective panel with contacts so arranged in the control, that the contactors of the protective panel will be closed at the first point in either direction and opened when the controller is at the off point.

(c) It is preferable to break the circuit by the contactor instead of the controller, which will reduce maintenance.

Control for Cranes

16. (a) The control for cranes to be of the design most suited to the operating requirements and space available, should conform to the general specifications and have plain visible markings in raised letters "forward—off—reverse." All wearing parts accessible and easily replaced without breaking connections or removing the controller from its position in service.

(b) To be provided with positive movement for making full contact at each point to avoid possibility of controller being left on intermediate points and burning contacts; also have a positive stop latch for the off point with release button in the handle, to prevent accidental starting or sudden reversing.

(c) To have sufficient points forward and reverse for smooth, even acceleration.

(d) Wire entrances to be equipped with insulated bushings, to prevent vibration from grounding wires on frame.

(e) Terminals to be plainly and permanently marked in accordance with wiring diagram mounted in cover.

(f) Fingers to be of such design that the pressure may be easily adjusted and remain where set by use of adjustable stops. Shunts of extra flexible braided material of sufficient capacity to carry full load current to be supplied where necessary.

(g) When current exceeds the capacity of one standard contact finger, two or more standard fingers are to be used instead of odd size fingers.

(h) The number of sizes of controllers should be reduced and parts made interchangeable, to reduce the number of spare parts to a minimum.

(i) Cranes having manually operated controls should have protective panels equipped with knife switch, magnetic contactors or circuit breakers, to protect the motor circuits and the complete system.

(j) All hoists to be provided with quick break limit switches so arranged that the hook may be lowered without resetting and to automatically reset when the hook has been lowered a short distance.

(k) For crane motors of above 50 hp., semi-magnetic or full magnetic types of control with small master controls are recommended on account of the great effort required to operate large manual controls. Also on account of their greater durability and providing the operator a better view of the crane operation and movement of the load.

Control for Pumping Plants

17. (a) All pumping plant controls should be designed to operate on wide voltage variation in the lines, not less than 10 per cent above and 15 per cent below the rated voltage. If the range is greater, the specification should state the range of variation, and the time limit should be given to show whether momentary or over a period of several minutes. Due to the importance of keeping pumps going the motors and controls should operate over the wide range of voltage variation as specified.

(b) The controls should be for heavy duty service and for slip ring motors designed to withstand continuous operation in any accelerating position without serious damage.

18. (a) Pump controls may be divided into three classes:

1. Manual or push button start and stop, provided with low voltage protection or low voltage release, as desired.
2. Manual or push button start and automatic stop provided with low voltage protection or low voltage release, as desired.
3. Full automatic start and stop.

(b) For large important pumping stations, class 2 control is preferred, as it requires the operator to see that pumps are properly primed and leaves no excuse for failures.

19. In moderate climates, float switches can be used, but in colder climates, pressure regulator control piped to a point where there is no surge or water hammer or a surge tank should be arranged for the connection, which should not be in lines from which large outlets are taken for water cranes, etc., that would cause the motor to start each time a large outlet is opened.

Control for Air Compressors

20. (a) For compressors using a.c. motors, up to 25 hp., the motors can be of squirrel cage type. From 25 to 150 hp. they can be slip ring wound rotor type motors. For larger sizes, they should be synchronous motors.

(b) The controls should be for heavy duty service and for slip ring motors designed to withstand continuous operation in any accelerating position without serious damage.

21. Air compressor controls for small machines operating on yards or at shops, where the demand is small and irregular, should be automatic start and stop type, with pressure control set for 10 to 20 lb. variation. When it is desired to have the compressor remain idle, the main switch can be opened. An unloading device should be part of the compressor equipment, to maintain unloaded condition until the motor has attained full speed.

22. The compressors for larger operations at shops and terminals, requiring fairly constant demand of air, should be manually or push button controlled and the motor run continuously with the demand variations controlled by the unloader set at 10 to 20 lb. variation, as desired. This is more economical than having a large motor driven compressor start and stop as the demand varies, except in operations where the demand is over widely separated periods that would permit the motor to stand idle for 15 minutes or more, and there are very few such operations on railroads.

Control for Heavy Duty Coal and Ore Handling Machinery

23. The requirements for this class of service are necessarily automatic or semi-automatic controls, and the functioning of the equipment requires features not found in ordinary controllers. A large number of such installations require two motors geared to the same shaft, in which event, the motors must be made to divide the load equally. For this reason, all control panels for this type of equipment should be equipped with an ammeter for each motor, ammeters to be mounted close together for ease of observation.

24. The elevator and dumper equipment should have double scale meters with zero in center for forward and reverse movement, as it has been found in some cases, one motor would be carrying all the load or dragging the other. The controls in other cases operate one motor as a generator for dynamic braking on the return movement.

25. (a) All controls should be heavy duty with the simplest form of interlocking arrangement possible, for safe operation.

(b) All contactors and terminals should be plainly and per-

manently marked, and the adjustments so arranged that they will not work loose from vibration, and may be set with ordinary pocket tools.

(c) The resistance units used in circuit with contactor coils to be of the ferrule type, for ease of removal and replacement, and be plainly marked on ferrules, showing ohms, to enable operators to quickly locate and replace such units. The panel for resistance units if used is to be located in an accessible safe place away from the bus bars and heavy panel wiring.

(d) The large terminal studs to be extra heavy with clean cut threads and double nuts. Bus bars and heavy wiring to give free access to the terminal lugs and permit removal of damaged contactors without undue delay in removing bus copper.

(e) All wearing parts to be easily removed and replaced. All coils and resistance units to be impregnated for moisture proofing.

(f) The controls to be so arranged that they progress through their proper functioning of series and parallel in succession should the operator throw the master control full over to the parallel point.

26. The series motor controls to be so arranged that any failure of control equipment will cause motors to stop and not race to destruction. This can be protected against by speed limit switch on end of motor shaft as part of control.

Respectfully submitted.

COMMITTEE ON STARTERS AND CONTROLLERS.

Report of Committee on Electric Welding

Outline of the Proposed Manual on Electric Arc Process Which Should Effect Economies on All Roads

Committee:—

E. Wanamaker, chairman, electrical engineer, Chicago, Rock Island & Pacific Railroad; E. H. Hagensick, electrical engineer, Union-Pacific Railroad; G. T. Goddard, general electrical foreman, Illinois Central Railroad; F. J. Hill, chief electrician, Michigan Central Railroad; G. E. Murray, electrical engineer, Grand Trunk Railroad; Ernest Lunn, electrical engineer, Pullman Company; A. M. Frazee, electrical engineer, Duluth, Missabe & Northern Railroad.

TO THE MEMBERS:

Your Committee begs to report that in line with the discussion at the semi-annual meeting in Atlantic City, it has prepared a questionnaire which will be mailed out to the mechanical heads of the various railroads shortly after the convention, as indicated herewith.

The electric arc welding process in railway work has developed so extensively that many railway mechanical officers have expressed the opinion that in view of such growth and use in locomotive and car equipment, and especially on such equipment as is offered in interchange, that it would be very beneficial to the railroads if a welding manual was developed that would show at least one safe way for applying the electric arc welding process for each type or kind of job that may be safely and economically performed.

Extensive instructive work of this nature has been perfected for the use of oxy-acetylene welding and is available from many sources, but it seems no extensive effort has been made in co-ordinating the best practices for the application of electric arc welding. The Association of Railway Electrical Engineers has appointed a committee to develop such a manual for electric arc welding which they can—upon completion—present to the Mechanical Division of the A. R. A. for its study and use, should they so desire.

A study has revealed that many railroads have not received full benefits to which they are entitled from the use of the electric welding process, due to their inability to obtain authentic, reliable instructions and practices for their safe guidance in the use of this process.

In view of the existing conditions, the A. R. E. E. is endeavoring to collect from as many railroads as possible, a list of all jobs that are being successfully welded on their individual properties, in order that such applications as have been tried and proven may be included in the manual prepared by the electric welding committee

It is understood that several roads now have in existence excellent, up-to-date, electric welding manuals, instructions and practices, covering all of the important welding jobs performed.

As soon as sufficient data and information can be collected from the various roads, it is the intention of the Committee to invite a number of railroads to volunteer the services of one of their welding and mechanical officers to meet with the Committee, so that at least one good method of application for each job be recommended in the manual as satisfactory.

It is felt that such a manual, properly gotten up and maintained up to date, will do much to promote the safe and economic use of this process, and to this end the hearty co-operation of all of the railroads is requested.

In getting up this manual, as a general guide for the application of electric arc welding to the different classes of metals generally used on railroads, the practice employed should be described, including before and after treatment, if any, for the welding of the different metals as follows:

1. Cast steel castings.
2. Rolled steel plates and shapes.
3. High carbon steel.
4. Wrought iron plates and shapes.
5. Gray iron castings (cast iron).
6. Malleable iron castings.
7. White iron castings.
8. Galvanized iron and steel plates.
9. Bronze, brass and other non-ferrous metals, including aluminum.
10. Alloy steels, including tool steel and manganese steel.

It is recognized that the method and procedure required for each of the different metals in use vary widely, depending upon the nature of the service. For example, a common cast steel casting between engine and tender may be restored to dimensions by the use of a metal applied by the electric arc without further treatment and satisfactory service obtained, whereas a worn cast steel coupler shank, when restored to dimensions by the use of a metal applied by the electric arc, should afterwards be annealed, in order to obtain safe and satisfactory service.

In view of this, detailed description—and prints where possible—are desired on some of the more important welding applications, as follows:

Locomotive firebox welding, including type of joint and procedure of applying metal, and where applied in sections, the order of the sections.

Welding of large and small flues, stating whether or not the boiler is filled with hot or cold water during welding, and advantages claimed.

Welding of locomotive frames, including an example of horizontal and vertical members—whether before or after treatment is employed.

The welding of motion parts, exclusive of main and connecting parts, on which welding is not permitted, describing method, and treatment before or after, if any, for each part.

Welding of locomotive cylinders and other cast-iron parts, giving detailed methods employed.

In addition to the above, as much information as consistent on the welding of parts, as follows:

Tender tanks—both repair and construction.

Freight and Passenger Car Equipment:

Truck sides.
Bolsters.
Couplers.
Axle journals and other castings.
Car frame fabrication, and any other important applications.

Shop Equipment:

Information as to the use of arc welding in the repair and maintenance of shop facilities and equipment will be valuable

and should be included, as, for example, the welding on of tool tips and the building up of worn machinery parts.

Track Welding:

While the use of the electric arc in the repair and maintenance of track parts—frogs and crossings—has not been so extensive that a great deal of very valuable work has been done, it is requested that as much detailed information as consistent be given of such work as may have been performed by each road, including the building up of manganese steel track parts.

It is realized that the information requested will require considerable effort, but it is felt that the effort will be well rewarded when the complete information has been assembled and perfected for the mutual benefit of all.

Your Committee has already collected a large quantity of data to be checked and incorporated in the manual during the coming year.

After studying the manuals that have been prepared by different railroads, your Committee concluded that the form of manual should be loose-leaf, standard letter size.

Your Committee has also made a study that will enable them to draw up a definite method of specifying the size of electric arc welding equipments in such a manner that the various manufacturers can bid on same by using their own equivalent specification; that is, the A. R. E. E. Manual Specification will make it clear to the buyer of a welding equipment as to the actual capacity of the equipments offered him for purchase, regardless of the way in which the specification is expressed by the individual manufacturers.

Your Committee has undertaken quite a large task, and the hearty co-operation of all of the members of the association is very much desired.

Respectfully submitted,

COMMITTEE ON ELECTRIC WELDING.

Report of Committee on Economics of Electrical Appliances

Data Gathered Shows That Large Savings Have Been Effected By Installing Electrical Devices

Committee:—

E. A. Lundy, chairman, E. A. Lundy Company; J. A. Andreucetti, assistant electrical engineer, Chicago & North Western Ry.; G. W. Bebout, electrical engineer, Chesapeake & Ohio Ry.; E. H. Hagensick, electrical engineer, Union Pacific Railroad; R. G. Gage, electrical engineer, Canadian Pacific Railway; George E. Murray, mechanical and electrical engineer, Grand Trunk Railway.

TO THE MEMBERS:

The railroads of this country are confronted with the serious problem of lowering operating costs and speeding up production. Electrical applications have demonstrated their value time and time again in this regard.

The Association has for some time felt that if definite data could be collected showing the various economies effected by electrical applications, and brought to the attention of railway officers that it would help materially in getting a greater appreciation for this end of the work.

It was with this thought in mind that this Committee was appointed. The following paragraphs together with the table which accompanies this report, will show that the economies effected by certain electrical applications have been large and also, that in a number of cases, better service was an important item.

Believing that a detailed analysis of the typical examples furnished by the roads, showing just how the economies were brought about would be of interest, the most important of those are enumerated below.

Pumping Stations

BALTIMORE AND OHIO.

Present yearly net savings, $1,740. Approximate return, 58%.

Chiefly by elimination of labor.

CENTRAL OF GA.

Present yearly net savings, $419.88. Approximate return, 27.26%.

Steam plant replaced by electrically driven, automatically controlled centrifugal pump. Pump controlled by float switch in top of tank one mile from pump. Saving effected by releasing pumper.

C. & N. W. RY.

Present yearly net savings, $6,000. Approximate return, 100%.

By electrical operation (Automatic) we were able to save on labor, fuel and switching charges and give better service.

C. I. & L. RY.

Present yearly net savings, $1,542.92. Approximate return, 95%.

Elimination of pumpers, reduction of fuel, oil and shop expense, compared to current, labor of signal men and pump repairman. All new equipment contemplated is electric.

C. C. C. & ST. L. RY.

Present yearly net savings, $150. Approximate return, 20%.

Cost of operating steam plant, $6,400 per annum.

Cost of operating electric plant, $4,000 per annum.

Fixed charges on additional investment, $800 per annum.

Saving of $1,500 per annum.

Pumps automatically operated, saving pumpers' wages.

LONG ISLAND RAILROAD.

Present yearly net savings, $900. Approximate return, 36%.

Savings realized by reducing labor charge as well as slight reductions in maintenance as regards fuel and boiler inspection.

MAINE CENTRAL R. R. & PORTLAND TERMINAL CO.

Present yearly net savings, $3,497.76. Approximate return, 134½%.

Labor and coal account for savings.

N. Y. O. & W. R. R.

Present yearly net savings, $12,500. Approximate return, 40%.

Automatic control eliminating attendance is greatest factor and greatly decreased maintenance of electric drive as against steam plants.

N. Y. N. H. & H. R. R.

Present yearly net savings, $11,036. Approximate return, 284%.

Savings realized by elimination of boiler plant, electric generators and labor and sub. of purchased power.

Saving is $2,800 per year as average.

NORFOLK & WESTERN.

Present yearly net savings, $6,000 (Est.). Approximate return, 35% (Est.).

By electrical operation were able to cut off men necessary for handling coal, etc., and saving in fuel necessary for steam operation.

NORTHWESTERN PACIFIC.

Present yearly net savings, $204. Approximate return, 63.5%.

Eliminated attendant at $14 per month. Gas engine replaced by automatically controlled electric motor with estimated saving of $3 per month in energy, maintenance and depreciation charges.

PEORIA & EASTERN RY.

Present yearly net saving, $4,000. Approximate return, 46.28%.

Paid water company average of $7,000 per annum for water. By installing duplicated centrifugal pumps, electrically driven, power charge averages $3,000 per annum.

Saving of $4,000 per annum.

PERE MARQUETTE RAILWAY.

Saving of 50%.

Dispensing with pumpers and low rate for power.

WABASH RAILWAY COMPANY.

Present yearly net savings, $2,800—one installation. Approximate return, 43%.

Difference in cost of coal and electric current, $780.

Decreased maintenance, $100.

Reduction in operating labor, $1,920.

LOS ANGELES & SALT LAKE.

Present yearly net savings, $1,900. Approximate return, 20%.

OREGON SHORT LINE RAILROAD.

Present yearly net savings, $18,000. Approximate return, 50%.

Reduction in electric power vs. coal, labor, fixed charges saved, switching coal.

ANALYSIS OF SAVINGS EFFECTED BY ELECTRICAL APPARATUS

Miles of line	Railroad	PUMPING STATIONS: Analyses of original recommendation: Stations electrically equipped to replace gas, steam or other drive	Stations where better service was the controlling factor	Stations where decreased maint. was the controlling factor	Stations where labor saving was the controlling factor	Stations where fuel saving was the controlling factor	Stations where saving in fixed chgs. was the controlling factor	PUMPING STATIONS: Economies effected for one installation: Present yearly net savings	Approximate per cent return on investment	How savings were realized	COALING STATIONS: Analyses of original recommendation: Stations electrically equipped to replace gas, steam or other drive	Stations where better service was the controlling factor	Stations where decreased maint. was the controlling factor	Stations where labor saving was the controlling factor	Stations where fuel saving was the controlling factor	Stations where saving in fixed chgs. was the controlling factor	COALING STATIONS: Economies effected for one installation: Present yearly net savings	Approximate per cent return on investment	How savings were realized	ELECTRIC ARC WELDING: Number in service	D. C.	A. C.	Single operator sets	Multiple operator sets	Automatic arcs	Semi-automatic arcs	Butt welders	Spot welders
8,862	Atchison, Topeka & Santa Fe	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	....	106	106	0	96	7	..	..	3	..
5,187	Baltimore & Ohio	15	4	5	5	1	0	$1,740	58	L	7	2	4	1	..	..	$3,000	50	L F M	53	52	1	25	27	..	..	..	1
2,512	Boston & Maine	35	35	35	35	35	0	....	..	.....	1	..	..	..	..	..	....	..	.....	7	6	..	5	1	..	..	..	1
1,924	Central of Georgia	6	..	..	6	..	..	420	27	.....	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	..	..	..
8,402	Chicago & North Western	56	56	56	56	56	..	6,000	100	L F M S	39	39	..	39	..	..	....	..	.....	29	28	1	24	4	..	..	..	1
654	Chicago, Ind. & Louisville	6	6	6	6	6	4	1.543	95	L F M S	..	..	..	..	..	..	....	..	.....	5	..	..	5	..	..	..	..	..
2,416	C. C. C. & St. Louis	10	..	..	10	..	..	1,500	20	L	2	..	..	2	..	..	....	..	.....	13	12	1	..	..	..	..	..	..
873	Delaware & Hudson	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....	4	3	1	..	..	..	..	..	..
459	Elgin, Joliet & Eastern	5	5	5	5	5	5	....	..	.....	3	..	..	..	..	..	....	..	.....	2	2	..	1	1	..	..	..	..
6,180	Illinois Central	46	46	46	46	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	..	..	..
836	Kansas City Southern	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....	4	4	..	2	1	..	..	..	..
1,442	Lehigh Valley	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....	12	11	1	7	5	..	..	5	..
395	Long Island	3	..	..	3	3	3	900	36	L M	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	..	..	..
1,215	Maine Central	3	..	..	2	1	..	3,498	134	L C	..	..	..	..	..	..	....	..	.....	4	..	..	3	1	..	..	..	..
1,247	Nashville, Chattanooga & St. L	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....	7	7	..	6	1	..	..	..	..
568	New York, Ontario & Western	8	8	8	8	8	8	12,500	40	L M	5	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	..	..	..
1,247	New York, Chicago & St. Louis	1	..	..	1	..	..	....	..	.....	2	2	..	..	..	..	....	..	.....	10	1	9	8	2	..	..	..	..
2,183	N. Y., N. H. & Hartford	22	12	0	7	0	3	11,036	284	L F M S	13	13	..	..	..	..	11,200	33	S	11	8	1	2	..	..	..	..	..
2,238	Norfolk & Western	1	..	..	1	1	..	6,000	35	L F	2	..	..	2	2	..	35,000	75	.....	33	33	..	7	26	..	..	2	1
6,656	Northern Pacific	40	40	30	14	16	..	380	5	L F	31	30	11	..	15	..	150	3	F L	5	5	..	..	..	..	..	..	..
508	Northwestern Pacific	5	5	5	5	5	..	204	64	L	..	..	..	..	..	..	....	..	.....	1	1	..	1	..	..	..	..	..
201	Peoria and Eastern	3	..	..	2	..	1	400	46	L Fx	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	..	..	..
2,229	Pere Marquette	22	7	3	8	4	..	50%	..	L P	12	4	5	2	1	..	30%	..	L P	7	5	2	7	..	5	2	..	..
1,127	Reading Company	17	..	..	..	..	..	....	..	.....	4	..	..	..	..	..	....	..	.....	13	13	..	..	13	..	..	..	..
413	Rutland Railroad	3	3	3	..	..	..	....	..	.....	4	3	1	..	..	..	....	..	.....	2	..	..	..	..	..	..	..	..
4,769	St. Louis-San Francisco	4	4	4	..	4	..	....	..	.....	..	..	..	..	..	..	....	..	.....	31	13	18	31	..	..	..	1	..
739	San Antonio & Aransas Pass	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....	3	3	..	..	..	..	..	..	..
7,117	Southern Pacific	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....	35	35	..	35	..	..	..	..	..
3,709	Union Pacific	13	13	..	..	..	..	....	..	.....	23	22	..	..	1	..	400	20	S F M	20	17	3	2	15	..	..	3	..
1,169	Los Angeles & Salt Lake	6	2	2	2	2	3	1,900	20	.....	..	..	..	..	..	..	....	..	.....	4	4	..	..	..	..	..	..	..
2,367	Oregon Short Line	12	..	12	12	12	1	18,000	50	M L F Fx	5	5	5	5	5	..	....	..	.....	4	4	..	4	..	..	..	..	..
2,238	Oregon, Washington R. R. & Navigation	4	4	4	1	4	..	10,000	68	S N L F	..	6	6	..	6	..	....	50	.....	3	1	2	..	3	3	..	..	3
2,473	Wabash	11	4	4	3	..	..	28,000	43	F M L	1	..	1	..	..	..	280	24	M	8	8	..	8	..	..	..	..	..

ANALYSIS OF SAVINGS EFFECTED BY ELECTRICAL APPARATUS

CAR AND LOCOMOTIVE SHOPS

Analyses of original recommendation

Economies effected for one installation

TURNTABLES

Analyses of original recommendation

Economies effected for one installation

Miles of line	Railroad	Shops electrically equipped to replace gas, steam or other drive	Motors installed	Engines replaced H. P.	Engines replaced	H. P.	Shops where better service was the controlling factor	Shops where decreased maint. was the controlling factor	Shops where labor saving was the controlling factor	Shops where fuel saving was the controlling factor	Shops where saving in fixed chgs. was the controlling factor	Present yearly net savings	Approximate per cent return on investment	How savings were realized	Turntables electrically equipped to replace gas, steam or other drive	Turntables where better service was the controlling factor	Turntables where decreased maint. was the controlling factor	Turntables where labor saving was the controlling factor	Turntables where fuel saving was the controlling factor	Turntables where saving in fixed chgs. was the controlling factor	Present yearly net savings	Approximate per cent return on investment	How savings were realized
8,862	Atchison, Topeka & Santa Fe	..	...	...	..	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....
5,187	Baltimore & Ohio	..	...	...	..	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....
2,512	Boston & Maine	..	...	...	..	..	..	..	..	..	..	....	..	.....	28	..	..	..	..	..	....	..	.....
1,924	Central of Georgia	..	...	...	..	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....
8,402	Chicago & North Western	7	130	2,548	10	..	4	4	..	2	..	....	..	.....	28	28	28	28	..	..	....	..	.....
654	Chicago, Ind. & Louisville	1	16	515	2	300	1	..	..	..	..	....	..	.....	4	4	..	..	..	..	$4,000	100	S
2,416	C. C. C. & St. Louis	5	...	...	6	590	..	..	2	5	2	$2,000	..	.....	23	23	..	..	..	..	....	..	.....
873	Delaware & Hudson	..	...	...	..	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....
459	Elgin, Joliet & Eastern	..	...	...	..	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....
6,180	Illinois Central	..	...	...	..	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....
836	Kansas City Southern	..	...	...	..	..	..	..	..	..	..	....	..	.....	4	4	4	4	4	4	....	..	.....
1,442	Lehigh Valley	5	32	943	8	685	8	7	7	2	2	3,500	6	S N	7	7	5	5	5	2	450	8	S M
395	Long Island	..	...	...	..	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....
1,215	Maine Central	3	191	2,488	4	425	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....
1,247	Nashville, Chattanooga & St. L	4	12	410	4	250	4	4	4	4	4	10,000	15	S M L F	3	3	3	3	..	3	16,108	100	S M L Fx
568	New York, Ontario & Western	..	...	...	..	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....
1,247	New York, Chicago & St. Louis	4	155	2,044	..	..	3	..	..	..	..	....	..	.....	5	5	..	..	..	..	....	..	.....
2,183	N. Y., N. H. & Hartford	5	15	350	5	400	5	..	..	..	..	....	..	.....	10	10	..	..	..	..	....	..	19
2,238	Norfolk & Western	..	...	...	..	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....
6,656	Northern Pacific	41	8,700	...	..	..	..	..	..	..	..	....	..	.....	24	24	..	..	..	..	....	100	S L
508	Northwestern Pacific	..	...	...	..	..	..	..	..	..	..	....	..	.....	1	1	..	1	..	..	....	100	S L
201	Peoria and Eastern	..	...	...	..	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....
2,229	Pere Marquette	3	13	1,100	3	650	3	3	3	3	3	60%	..	L P	7	7	7	7	..	7	10,080	..	L
1,127	Reading Company	8	...	...	..	..	..	..	..	..	..	....	..	.....	11	..	..	..	..	..	....	..	.....
413	Rutland Railroad	2	61	940	..	..	..	..	..	..	..	....	..	.....	3	3	..	..	..	..	....	..	.....
4,769	St. Louis-San Francisco	..	...	..	..	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....
739	San Antonio & Aransas Pass	2	24	225	2	150	..	..	..	2	..	14,400	120	L F	..	..	..	..	..	..	....	..	.....
7,117	Southern Pacific	..	...	...	..	..	..	..	..	..	..	....	..	.....	..	..	..	..	..	..	....	..	.....
3,709	Union Pacific	11	36	788	12	1,035	2	..	2	7	..	2,150	33	L F	17	17	..	..	..	..	....	..	.....
1,169	Los Angeles & Salt Lake	2	21	250	6	120	2	..	..	..	..	2,500	20	S	1	1	..	..	..	..	300	10	S M
2,367	Oregon Short Line	..	...	...	..	..	..	..	..	..	..	....	..	.....	8	8	..	8	..	..	....	..	.....
2,238	Oregon, Washington R. R. & Navigation	6	149	2,100	..	..	6	6	6	6	6	....	..	.....	8	8	8	8	8	8	....	..	.....
2,473	Wabash	3	77	1,463	4	..	3	..	..	..	..	4,000	24	M	11	..	11	..	..	..	150	18	M

S—Improved service. M—Decreased maintenance. L—Labor saving. F—Saving Fuel Fx—Saving fixed charges. P—Low power rate.

Oregon-Washington R. R. & Nav. Co.
Present yearly net savings, $10,000. Approximate return, 68%.
Dispense with two 150 hp. boilers, 3 firemen, 1 ash handler. Also net saving between electricity and coal.

Coaling Stations

Detailed information pertaining to Coaling Stations as shown in part in the table is given below:

Baltimore & Ohio.
Present yearly net savings, $3,000. Approximate return, 50%.
By eliminating labor, fuel and maintenance on old steam power plant.

C. I. & L.
All coaling stations originally electrically equipped.

N. Y. N. H. & H. R. R.
Present yearly net savings, $11,200. Approximate return, 33%.
More efficient service.

Norfolk & Western Ry.
Present yearly net savings, $35,000 (Est.). Approximate return, 75% (Est.).
By electric operation were able to cut off men necessary for handling coal, etc., and saving in fuel necessary for steam operation.

Pere Marquette Railway.
Present yearly net saving, 50%. Approximate return, not known.
Labor and low rate for power.

Wabash Railway.
Present yearly net savings, $280. Approximate return, 24%.
Decrease in maintenance labor.

Union Pacific R. R.
Present yearly net savings, $400. Approximate return, 20%.
In reduced expenditure for fuel, supplies and maintenance.
The change also resulted in more reliable operation.

Car and Locomotive Shops

The typical examples as shown in the table for Car and Locomotive Shops are given in detail below:

C. I. & L. Ry.
Installation of motors was not for saving but for efficiency and because of lack of power generated by power plant.

C. C. C. & St. L. Ry.
Present yearly net savings, $2,000. Approximate return on investment.

Lehigh Valley Railroad.
Present yearly net savings, $3,500. Approximate return, 6%.
Decreased maintenance; also less delay in making repairs to equipment passing through shop.

Nash. Chatt. & St. L. Ry.
Present yearly net savings, $10,000. Approximate return, 15%.
Replaced slide valve type stationary engines with A. C. motors.

Pere Marquette Railway.
Present yearly net savings, 60%. Approximate return not known.
Low rate for power and reduction in labor costs.

San Antonio & Aransas Pass.
Present yearly net savings, $14,400. Approximate return, 120%.
Difference between cost of electricity and fuel, plus labor and maintenance of steam plant.

Wabash Railway.
Present yearly net savings, $4,000—one installation. Approximate return, 24%.
Permitted the shutting down of stationary plants except during the heating season.

Union Pacific R. R.
Present yearly net savings, $2,150. Approximate return, 33%.
Due to more economical operation, and saving the wages of one engineer.

Los Angeles & Salt Lake.
Present yearly net savings, $2,500. Approximate return, 20%.

Oregon Short Line Railroad.
All shops have been equipped with electrically driven machines for many years. This has resulted in more economical operation.

Oregon-Washington R. R. & Nav. Co.
Less first cost. maintenance and low power rates compared to boiler installations, steam engines and fuel costs.

Turntables

The typical savings for the turntables show several interesting installations.

C. I. & L. Ry.
Present yearly net savings, $4,000. Approximate return, 100%.

Lehigh Valley Railroad.
Present yearly net savings, $540. Approximate return, 8%.

N. C. & St. L.
Present yearly net savings, $16,108.40. Approx. return, 100%.
Moving dead engines—spotting engines—relieving 8 laborers—per day—3 shifts.

Northwestern Pacific.
Turntables had been previously hand operated. Approximate return, 100%.

Pere Marquette Railway.
Present yearly net savings, $10,080. Approx. return, not known.
Labor of one man each table.

Wabash Railway.
Present yearly net savings, 1 inst., $150. Approx. return, 18%.
Maintenance of electric tractors is approximately $150 per year less than maintenance of other types of drivers.

Los Angeles & Salt Lake.
Present yearly net savings, $300. Approximate return, 10%.
Less upkeep on electric motor than air motor.

Oregon Short Line Railroad.
The electric driven turntables have been in service many years. This expedites turning of power.

Electric Arc Welding

The information given for the typical examples of electric arc welding show many worthwhile economies:

C. C. C. & St. L. Ry.
Savings in labor in repairs to leaky flues.
Savings in material by building up worn parts.

E. J. & E. Ry.
Saving of 50% effected by use of electric arc on such work as welding flues, fire boxes, tanks, cabs, etc.

Lehigh Valley Railroad.
Arc welding on firebox sheets at the system shops reduces cost about 40%.
Butt welder results in saving of about 75% on flue work.

N. C. & St. L.
Electric flue-welder. Cost of old way 10c per 2-inch flue; cost of present 1c per 2-inch flue.

N. Y. N. H. & H. R. R.
Better service.

Northwestern Pacific.
Welding of engine frames, saving of labor, material and time of engine out of service incident to this work.

Pere Marquette Railway.
Approximately $3,000 per annum each machine.

San Antonio & Aransas Pass.
Reclaiming cast steel locomotive parts, viz., driving boxes, locomotive frames, truck frames, coupler castings, coupler knuckles and other cast steel parts of locomotives and cars.

Los Angeles & Salt Lake.
Locomotive driving tires can be built up with electric welder in 4 hours as against 8 hours with the oxyacetylene. Saving, approximately 75c per hour.

Oregon Short Line Railroad.
Saving in labor due to eliminating forge welds. Saving due to eliminating dismantling of machinery. Electric welding of boiler flues in place reduces labor and keeps locomotives in service for longer periods of time.

Additional Apparatus

The following information was given in addition to the specific information requested.

C. & N. W. Ry.
Installation of a crane for cinder handling. Saving of $7,000 per year—labor.

C. C. C. & St. L. Ry.
Air-compressors used in yards for testing and charging train lines.

LEHIGH VALLEY RAILROAD.

Have in use about 85 electric trucks. Five at one point save approximately $8,400 annually in labor and more rapid handling of material; one at another point saves $1,000 annually.

N. C. & ST. L. RY.

1½ ton storage battery crane truck does work equivalent of 8 men.

N. Y. N. H. & H. R. R.

Eleven electric motor driven air-compressors aggregating 2,514 hp. Service was the controlling factor. Due to the fact that engines formerly used were in bad condition electric driven compressors were installed. Other economies were effected but were of secondary importance.

NORTHWESTERN PACIFIC.

Air-compressors at three locations changed from steam engine to electric motor drive. Steam hammers changed to air drive from electric driven compressors. Electric driven locomotive hoist.

PERE MARQUETTE RAILWAY.

One air-compressor motor driven service increased 75% saving, approximately $10,000 per annum on labor and power factor correction.

RUTLAND RAILROAD.

One cinder conveyor—decreased labor cost was determining factor. Saving unknown.

SOUTHERN PACIFIC

Trucks and tractors are used for freight handling and baggage handling at some points with considerable economy over the hand method of doing this work. All new air-compressors are electrically driven and in some cases steam driven compressors are being replaced by electrically driven compressors, as a matter of economy in fuel cost.

WABASH RAILWAY.

Eight electrically driven air-compressors effecting a saving of approximately 10% over steam.

UNION PACIFIC R. R.

Crane type truck in roundhouse for handling heavy parts. Fixed charges on crane are about $2 per day. A saving of 50% of man hours required for above operations can be effected as compared with ordinary method of using chain blocks hung from roof truss.

OREGON SHORT LINE RAILROAD.

Saving in purchased power, made by consolidating all service with transmission lines and taking one point at higher voltage and better load factor.

OREGON-WASHINGTON R. R. & NAV. CO.

Electric transfer table operating between machine shop, car repair, boiler shop, etc., carrier mechanism running on depressed tracks. Better service controlling factor. Saving not determinable.

A careful analysis of the table and the above paragraphs will show conclusively that electrical applications are an economic necessity and that their universal use will make possible a more economical operation of our roilroads with a resulting speeding up of transportation.

The Committee feels that an intensive educational campaign to railway engineers and officials will ultimately result in an increased usage for electrical equipment and the resulting economies.

The purpose of this campaign should be to show the railway officers and men by means of specific operating data, how certain definite advantages may be derived through the electrification of their facilities.

To convince the railway officers and engineers of the importance of a competent and authoritative electrical department and of the necessity of modernizing present shop facilities and other branches of railway activities.

Technical magazines that are read by the railway men could assist this cause materially in their editorial columns. The manufacturers of electrical equipment in the advertising pages of these papers would also help the cause by having their copy feature economical phases.

The Committee feels that the report this year is merely a start in the right direction and hopes that the information may be of some assistance in furthering the cause of electrical appliances on the railroads.

The Committee wants also to thank all those that have assisted in compiling the information that has made this report possible.

Respectfully submitted,

COMMITTEE ON ECONOMICS OF ELECTRICAL APPLIANCES.

A Masonry Bridge in Northern Italy

Overhead Distribution and Contact Systems

Factors in Heavy Electric Traction Installations Which Make for Economy and Efficiency

By R. E. Wade
General Electric Company

BEFORE taking up the subject of this paper in more or less detail it is well to briefly consider the relative importance of the several major features which combine to make up an electrified railroad system.

Assuming that we are dealing with an existing railroad the three general features are:

1. Power Generation or Supply.
2. Motive Power.
3. Distribution and Contact System.

While all three features receive the attention of the best talent available and in some ways are of equal importance, it is self-evident that Power Generation or Power at the Source stands first.

Continuity of power supply at a reasonable cost must be guaranteed before electrification can be seriously considered. Duplication of units and years of experience in design and operation have eliminated this feature as a "system" problem except for continued effort toward economy.

While the motive power feature is still in process of development, and particularly when dense traffic is involved, it must be credited with due amount of importance. When the system is

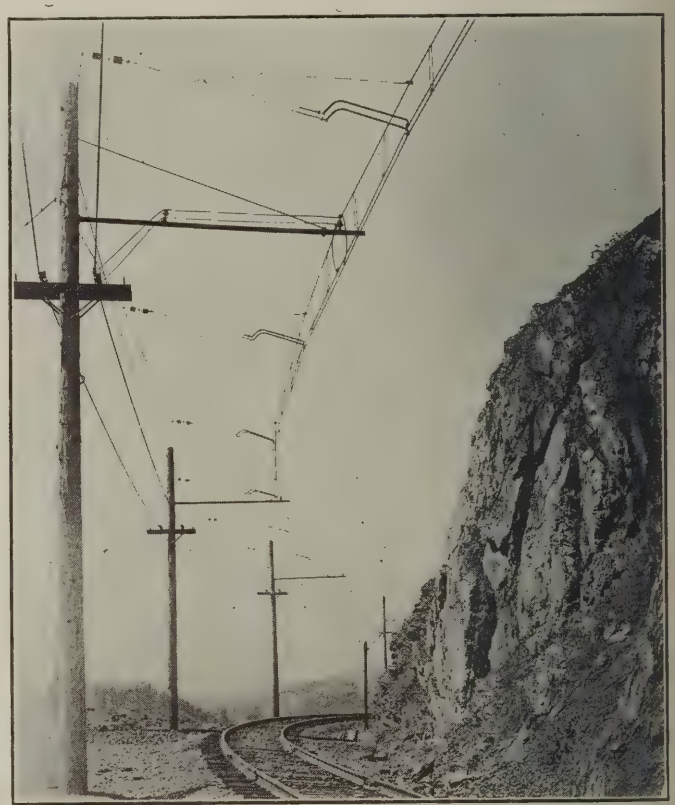
Simple Catenary Construction with Two Contact Wires. Shows Side Bracket Supports on Tangeut Track

considered as a whole, its subdivision into many units and development to date disposes of it as a "system" problem except as regards reduction of fixed charges or annual maintenance.

The third feature, distribution and contact system, which we have particularly in mind, can be logically considered as second in importance to power generation or supply from a railroad *system* standpoint.

It is the necessary connecting link between the source of power and the motive power units, and the importance of this link is emphasized on single track railroads. In fact, overhead distribution and contact system failures are in the same class with track failures, though this fact has been recognized only during the past twelve or thirteen years. Previous to that time, contact systems were left largely in the hands of purchasing agents and line foremen.

With the advent of heavy electric traction and the demand for the delivery of larger and larger blocks of power to motive power units, moving at high speed, distribution and contact systems began



Simple Catenary Construction, With Two Contact Wires Supported on Wood Poles. Shows Pull-Offs from Backbone on 10 Degree Curve

to receive the proper study and attention due them on the part of engineers and railroad operating men.

The general subject is both comprehensive and interesting.

The engineer responsible for their design, construction and operation comes in contact with:

Mechanical engineering in connection with overhead supporting structures and attachments, catenary system and feeders, with all fastenings and fittings;

Chemistry in connection with corrosion due to atmospheric and other destructive agents causing corrosion;

Local and general weather conditions as affecting structure and wire and cable loading and insulator performance;

Railroad construction methods and railroad practices as affecting structure design and location;

Railroad operation as affecting sectionalization of line and construction methods;

A general knowledge of insulation and electrical work.

Last, and not of less importance, a general knowledge of railroad men and their methods.

The duties of the distribution engineer require that he make

a careful and, sometimes critical, study of roadway, track conditions and maintenance. He must also give careful attention to classification of material, in connection with excavation and foundations, overhead obstructions, bridges, for structure attachments, wire crossings; and railroad, telegraph and other lines;

An Unusual Application of Side Bracket Supports on Tubular Steel Poles. Shows Direct Suspension for Contact Wires on 3-Phase Electrification

disposition of timber endangering lines; and many other details too numerous to mention are unexpectedly encountered.

It is sometimes necessary to check up right of way, alignment of tracks, side and over clearances, and similar points; and occasionally desirable to relocate certain tracks in yards, adjust superelevation on curves in the interest of structure economy and pantograph operation.

Development of Distribution and Contact Systems

While it might be interesting to trace the development of the distribution and delivery of current to electric cars and locomotives from the first experiments with street cars, for the purposes now in view it will suffice to say that the long familiar wheel collector, and method of suspending trolley or contact wires and feeders as used for street railway line are the results of many years of investigation and much creditable work.

This system of collection and distribution is reasonably satisfactory for small current values and relatively low speeds, and except for minor details has remained unchanged for a number of years.

Following the local street railway system came the interurban lines with heavier cars and with increased demands as to current and speed.

The natural way to meet the new conditions was to enlarge the wheel collectors and contact wires and fittings and use the same methods of installation and operation as were employed on street railways; and during this stage of development the requirements were very well met in that way.

Then came interurban systems with roadbeds suitable for the operation of heavy trains of cars at still higher speeds.

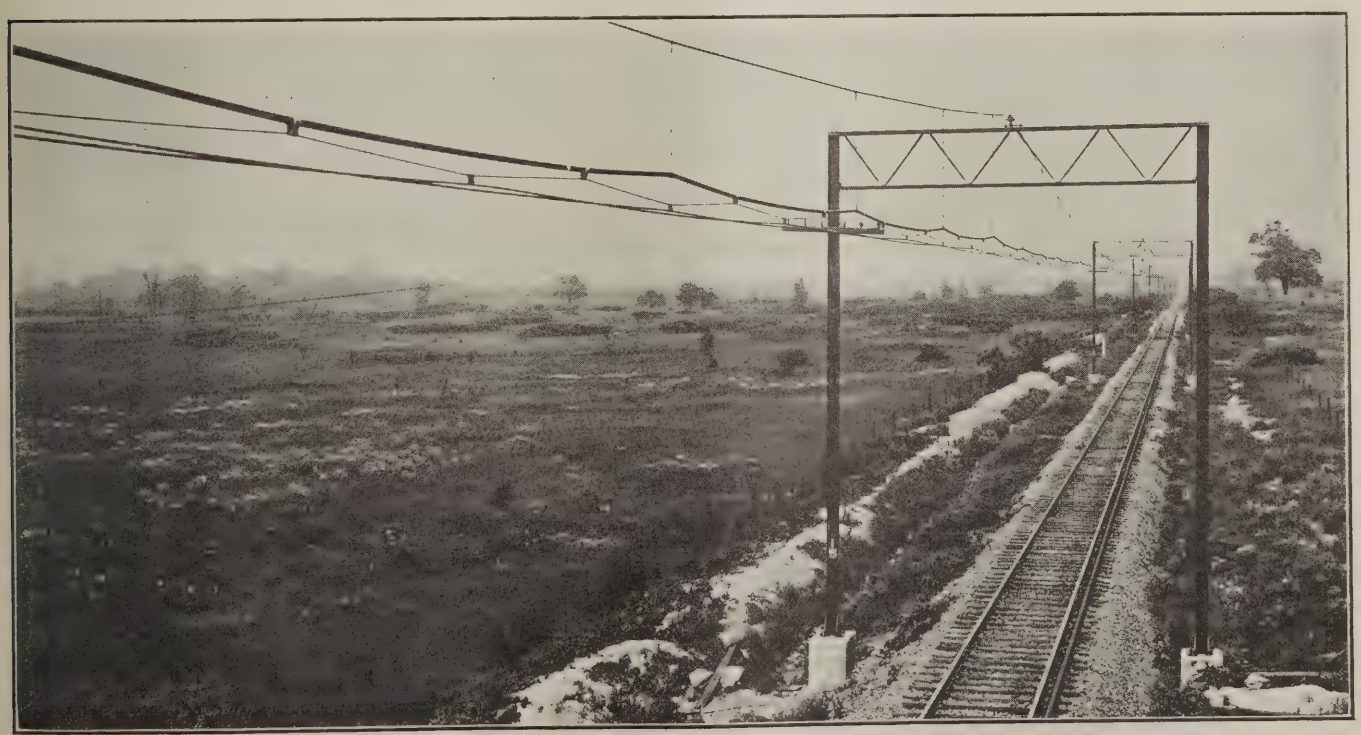
Engineers and operating officials began to realize the necessity for providing current distributing and collecting systems with certain characteristics not possessed by the overgrown street railway construction.

Finally came what is known as heavy electric traction, which involved the electrification of standard steam railways and the handling of heavier tonnage and with higher average speed than had been accomplished with steam motive power. Before proceeding further it is well to state that the term "distribution and contact system," as used in this paper, is intended to include supporting structures, insulation, feeders, contact wires, connections between feeders and contact wires, catenary strands, and fittings, and rail bonds.

The high voltage power transmission system, while generally involved, is not included.

Catenary System

The term "catenary system" is intended to include the overhead wires immediately over the tracks, namely, the catenary



Compound Catenary Construction With Steel Messenger, Feeder As Secondary Messenger and Laced Suspension for Two Contact Wires

or messenger wire; the auxiliary or secondary messenger, when used; the contact wire or wires; and the hangers and clamps used for fastening the above parts together.

Catenary systems, which have generally supplanted direct suspension systems for heavy work, are of two general types: *simple* and *compound*.

The simple type, which is generally limited to spans up to about 180 ft. in length, consists of the messenger or catenary, and contact wire or wires with suitable hangers.

The compound type, which is generally used for longer spans than those mentioned, consists of messenger, secondary messenger or auxiliary wire, and contact wire or wires. On existing work contact wires are suspended from secondary or auxiliary wires by means of loop hangers or clamps.

While there are a variety of catenary systems in use, they all possess one common feature—the main supporting member known as the catenary or the messenger. The principal differences in design concern the methods of supporting contact wires and adjusting them so as to satisfactorily follow track alignment.

Principles of Design

For a number of years distribution engineers have mutually agreed that either of two basic principles of design would provide a satisfactory contact member for heavy traction.

1. A perfectly rigid and smooth contact wire or member, installed and maintained at an absolutely uniform distance from perfectly rigid and smooth track rails.

This is obviously impracticable on account of economic and other reasons.

Two applications of this principle have been made—one, experimentally in France, when a fabricated steel truss with contact strip on under side was suspended over the track; and a commercial installation consisting of two steel strand messengers and one contact wire, in triangular relation, and assembled with triangular pipe frames, resulting in rigid spots at each pipe frame, with more or less flexible wire structure between. Both attempts were failures, the latter installation being modified to make it suitable for operation.

2. A uniformly flexible contact member, of uniform weight, in combination with track rails as maintained by the average better class railroad.

While the ideal as to flexibility and uniformity in weight has not been attained, it has been closely approached, and further improvements are being made from time to time.

Features Governing Design.—The principal points governing the design of an overhead catenary and contact system (except for proportioning of parts to meet load conditions and corrosive conditions) are: speed, amount of current to be collected, and type and characteristics of current collector used.

Speed and Current Collector.—Most heavy attraction propositions require provision for speeds up to sixty or seventy miles per hour, and the pantograph trolley is almost universally used for collecting current. In the United States, except for one or two instances, the collectors are fitted with pans. For small current values, a single sheet iron pan with a pressure of about 18 pounds on contact wire is used. With the heavier currents, two pans fitted with renewable contact strips and with a pressure of from 25 to 35 pounds are used.

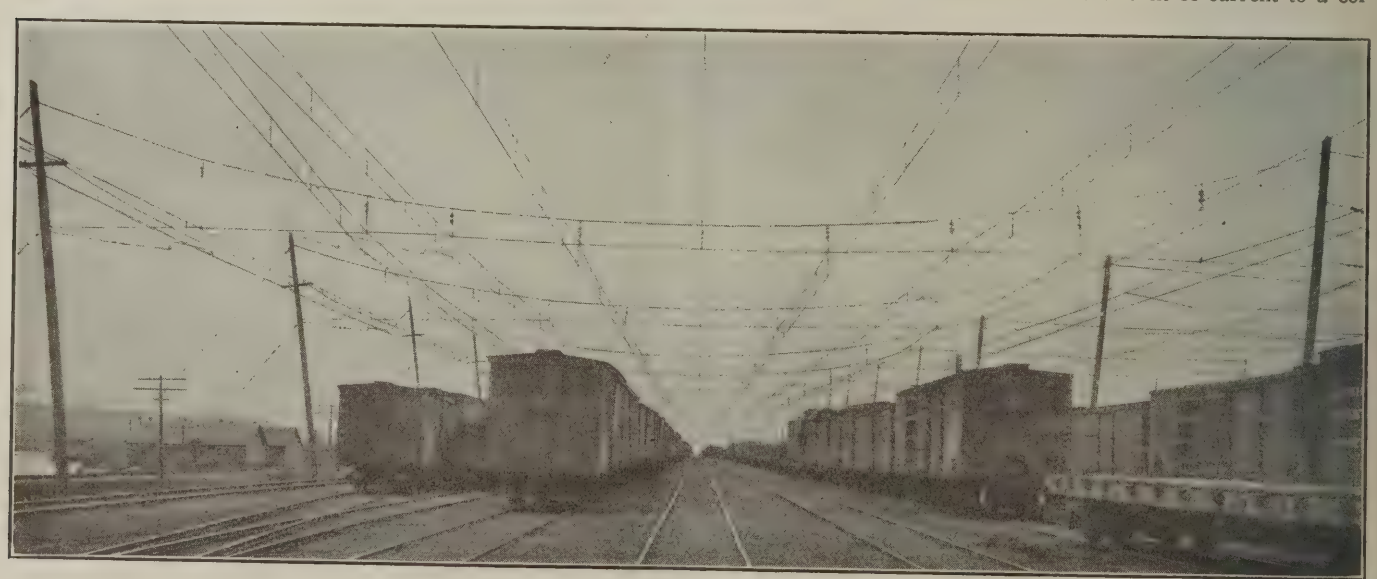
Overhead Special Work in Yard Showing Combination Catenary and Signal Bridges

Desirable Features in Contact Member Design.—It is desirable to provide a contact member:

(a) Which is subject to the least amount of mechanical wear and injury from collector.

(b) Which will deliver the desired amount of current to a collector, of practicable design, without sparking and consequent wear on this account. This means maintaining, as nearly as possible, uninterrupted contact between contact member and collector shoe.

(c) Which will operate without undue noise and will provide



Cross Catenary Spans on Wood Poles, Supporting Simple Catenary Construction for Nine Tracks

smooth and sparkless transition of collector at overhead switches, anchoring and sectionalizing points.

Current Collecting Capacity.—Current collected per pantograph varies between 80 and 800 amperes, while running, and with some

Modern Compound Catenary Construction on Swiss State Railways Shows Anchor Bridge with "H" Beam Columns

work now contemplated, may go as high as 3,500 amperes under acceleration.

With small current values, and reasonably flexible construction, collection can be successfully accomplished with one contact wire suspended by loop hangers. When current reaches 600 amperes, however, experience has shown the desirability of using two contact wires located in the same horizontal plane, and free to move independently in a vertical plane so as to have at least one flexible contact wire in contact with pans at all times.

With such an arrangement currents of 6,000 amperes have been collected at speeds of 30 m.p.h. and without sparking.

With these large current values it is necessary to maintain positive electrical connection between contact wires and other parts of catenary system, and recent developments have indicated the practicability of using a flexible strand or lacing for suspending contact wires from auxiliary wire.

Adjustment of Contact Wires to Curvature of Track

Two schemes have been used for this purpose:

1. Pulloffs from wires of the catenary system to the structures or bridles of steel strand fastened to structure.
2. Displacement of or offsetting messenger towards outside rail, with hangers; and auxiliary and contact wires in a resultant inclined plane.

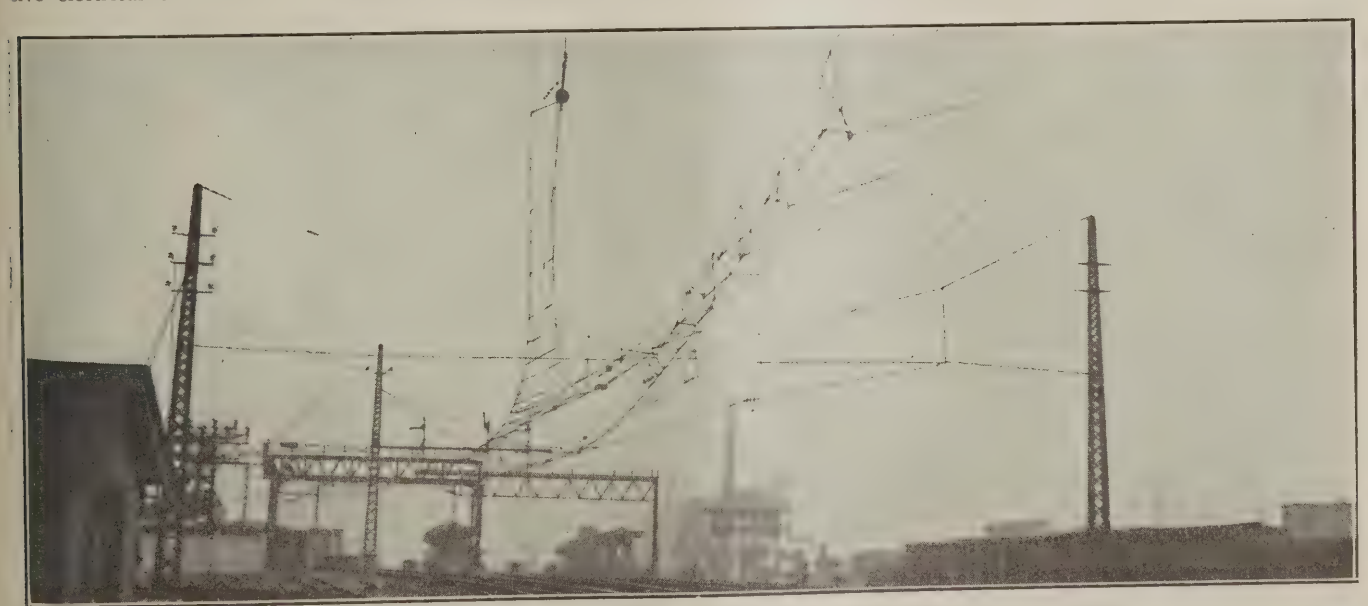
There is a technical objection to the first scheme on account of adding undesirable weight to the contact wires, and same objection to the general appearance of the construction. Experience does not justify the former objection.

The second scheme, however, does not function properly when curvature reaches a certain value, on account of higher stresses in horizontal plane with constant vertical weight per foot, and rigid hold-down attachments must be applied to contact wire or pulloffs resorted to.

Compound Catenary Construction on Heavy Curve. Shows Displaced Messenger Guyed Bridges and Pull-Off Poles with Tubular Steel for Columns

Tensioning of Wires.—Much time and money have been expended in European countries on attempts to perfect some device which will automatically maintain even tension in all wires of catenary system, particularly contact wires, during seasonal changes in temperature.

To date no satisfactory system has been devised, and experience in the United States has not proved the necessity for such a device.



Compound Catenary Construction Showing Displaced Messenger, Cross Catenary Span and Side Bracket Supports with Self Sustaining Steel Poles

The elasticity in line wires and supporting structures apparently supplies enough "spring action" to take care of the situation. Recent inquiries, addressed to railroads in the East, developed the interesting fact that, since their electrification some years ago, and though subjected to a wide variation in temperature and other seasonal changes, they have had no occasion to adjust tension in contact, auxiliary or messenger wires or cables.

Alignment of Contact Wires.—Some engineers argue in favor of staggering or displacing contact wires in a horizontal plane so as to distribute wear on pantograph shoe. It is possible that with low wire and unusually good track maintenance, that such displacement would be desirable, however, with wire from 22 to 24 ft. above rail, with the usual track conditions, and pantograph frame and locomotive spring flexibility, it is found that such treatment is not necessary.

Steadies for Catenary System.—With a 300 foot structure spacing, messenger and contact wires will probably need steady attachments at all structures, to prevent swaying of wires with collector and too much horizontal displacement by wind.

Wind pressure conditions must be studied on the ground from records and observations, and the proper treatment determined. It may be necessary to hold the wires between structures where wind pressure is heavy.

Anchorages for Catenary System.—There is a diversity of opinion as to the frequency of anchorages for catenary systems.

The general tendency is to make no special provision for anchorages other than those automatically provided at sectionalizing and other points.

Grade in Contact Wires.—The proper grade in contact wires, when reducing height on account of overhead obstructions, is largely dependent on type of catenary construction, speed, current collector, and characteristics of collector. A one per cent grade is largely used by high speed roads in this country, though grades as low as one-half per cent exist.

This point must be decided according to the facts in each case.

Materials for Catenary System

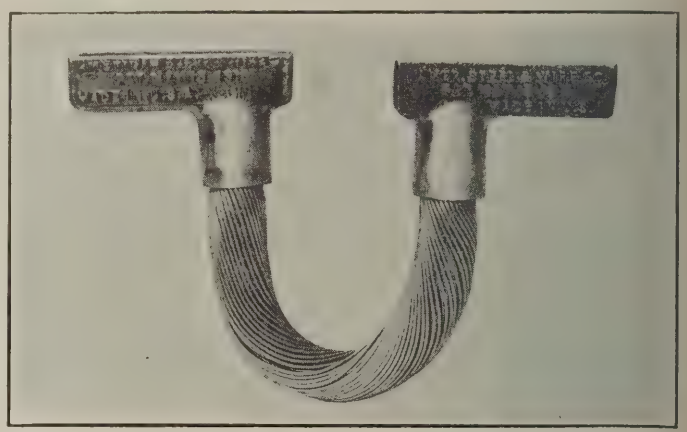
This important and interesting subject is being given close and universal study at this time, particularly in connection with corrosion.

(a) *Contact Wires.*—For contact wire use has been made of hard drawn copper, steel, and several of the higher tensile alloys coming under the general classification of bronze.

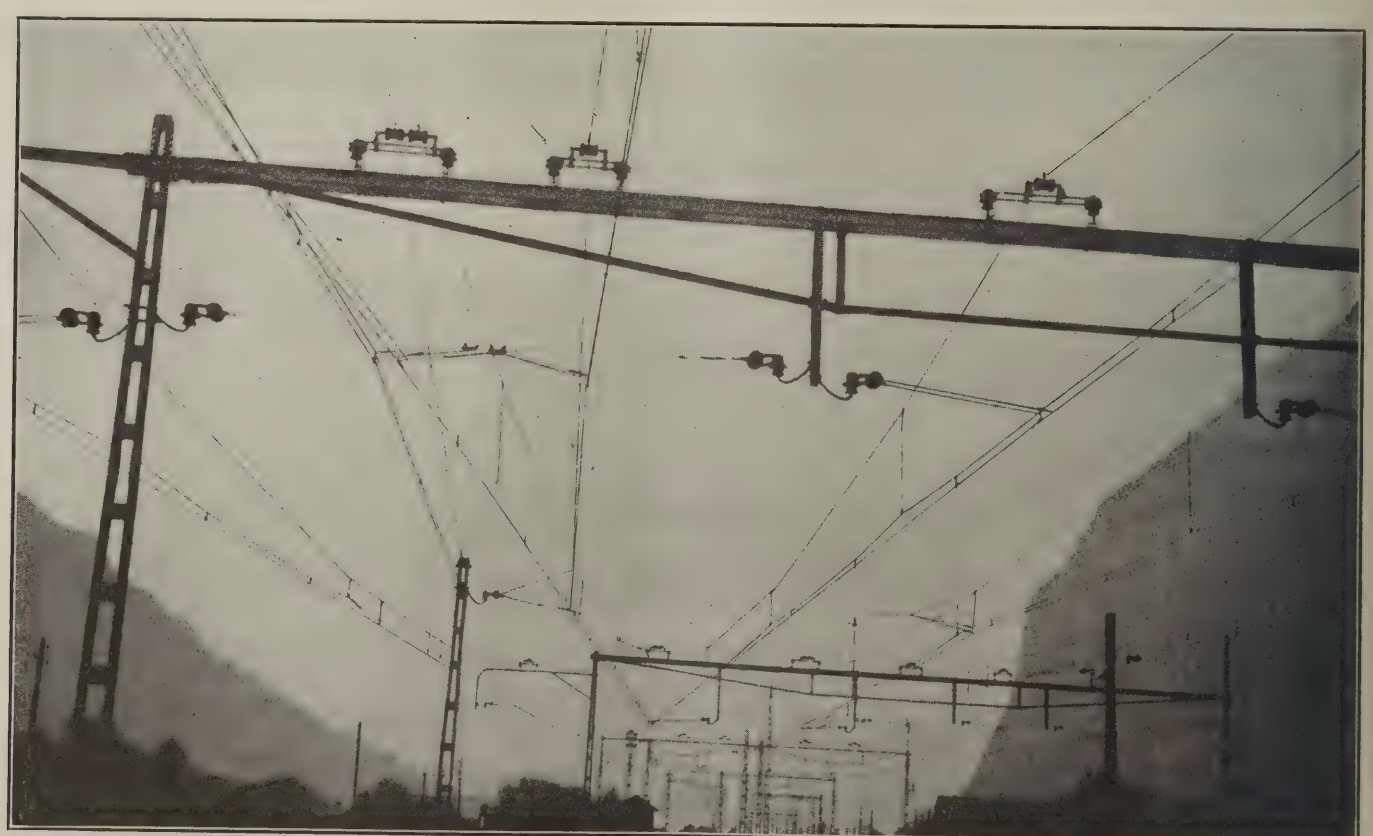
Steel has not been satisfactory on account of rusting and arcing, and is probably out of consideration as a contact member for overhead contact systems.

A comparison of the other two metals develops higher conductivity and lower cost in favor of copper; and longer life and better general physical characteristics for the bronzes.

The latter have much to recommend them when conductivity is not an important factor and when dense traffic calls for greater dependability and longer life.



Arc Weld Rail Bond for Application to Head of Rail



An Example of Compound Catenary with Loop Hanger Suspension for Contact Wire. Also Shows Double Insulation, Pull-Offs From Structure and Light Weight Steel Bridges

b) *Other Members of System.*—There are undoubtedly localities with dry air, free from destructive agencies, where steel with the best commercial galvanizing and sherardizing is satisfactory and economical.

When, however, the system is subjected to salt air, gases from locomotives (either during a long construction period, especially

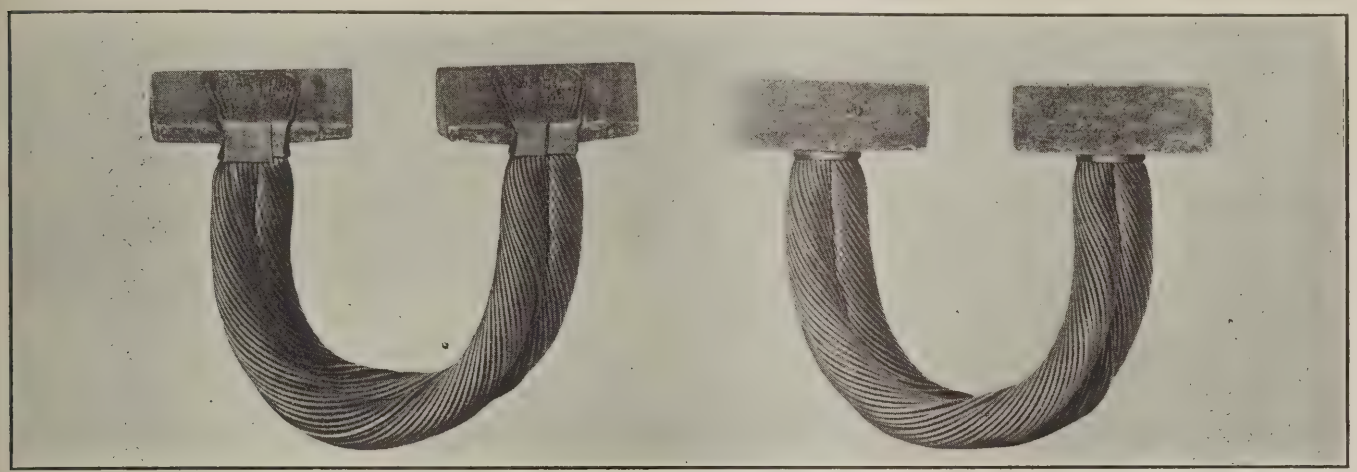
in moist climate, or permanently), smelters, coke ovens, or in some cases, cities, it is necessary to adopt some metal or combination of metals highly resistant to the destructive action of such agencies.

It has been found that the outer wires of a steel strand protect the inner wires from corrosion, and advantage is being taken of this fact by the various metal manufacturers in bringing out strands of various combinations for messenger with more or less non-corrosive metal forming the outside layer.

Some combinations use high tensile, protected steel for core, and some propose a high tensile, bronze core.

In all such strands considerable conductivity can be obtained together with high tensile strength.

When conductivity is not a factor in catenary system, consideration is being given to high strength alloy strand for messenger.



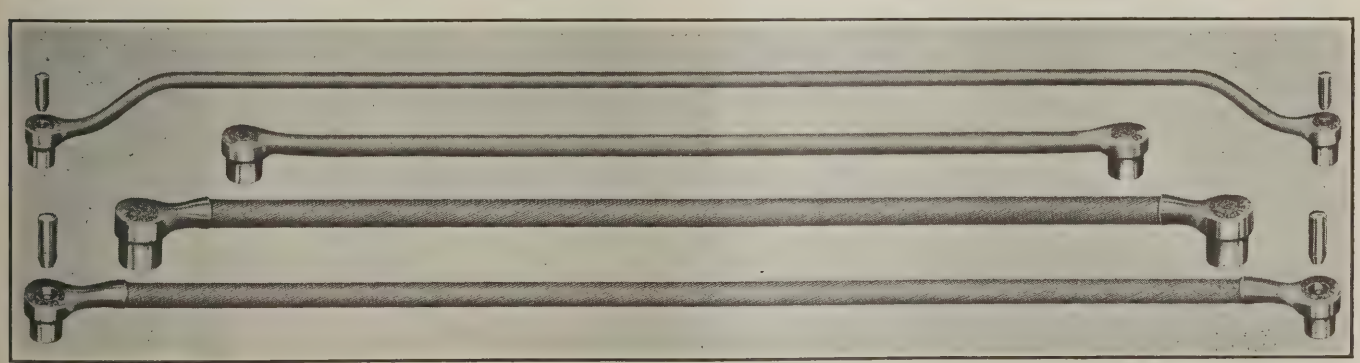
Gas Weld Rail Bond for Application to Head of Rail

(c) *Fittings.*—When special corrosive conditions are to be met, all catenary fittings should be of non-ferrous metal.

Supporting Structures

(a) *Material.*—Use has been made of wood, concrete and steel for this purpose, and it is probable that good arguments can be advanced for all three in special cases from the standpoints of economy and local conditions. It is also probable that steel will be used for the more important works, at least east of the Mississippi River, for some time to come.

Factors governing the selection of type of structures and material for structures are: Reliability; Economy; Appearance.



Solid Stud and Tubular Stud Railbonds

It is not impossible that if roads were close to the source of supply, and transportation charges small, western cedar poles, with their excellent characteristics as regards mechanical strength, long life and good appearance, would at least answer the first two requirements mentioned for single and double track work. Some of the power companies in the Northwest have abandoned steel in favor of wood, for 110,000-volt lines, purely on account of economy, with first cost, depreciation and all fixed charges taken into consideration.

Life at ground level is prolonged by butt treatment and concrete renewal stubbs, applied to that portion of pole above ground, eliminate the eventual necessity for disturbance of line wires when repairs must be made.

The use of concrete poles has been confined principally to street railway and power and light distribution work. The majority of these poles are of the solid reinforced design, though some use has been made of the hollow reinforced pole.

When properly made, of proper materials, concrete poles possess the maximum life characteristics. They are, however, relatively expensive and more or less limited in application as is the case with wood.

Furthermore, they are subject to a great variation in quality on account of liability of variation in workmanship and material.

The hollow pole, when made in a centrifugal machine, owing to the great density of concrete, has special strength, elasticity and resistance to moisture penetration. The latter point being valuable in connection with protection of reinforcing steel.

Structure design must be determined by careful study of the conditions in each case.

(b) *Types.*—For single track the familiar side bracket support has many advantages.

For two tracks and over, the self-sustaining bridge, guyed bridge or guyed cross span are used. The guyed structure is economical, and the cross span offers little interference with vision, but local conditions often prohibit the use of guys.

The general tendency in structure design is to provide minimum number of parts, with accessibility for painting, and minimum amount of shop labor and corrosion.

Insulation.—The superiority of modern porcelain as an insulator is generally recognized, and the disk or suspension insulator possesses many advantages over the pin or post type.

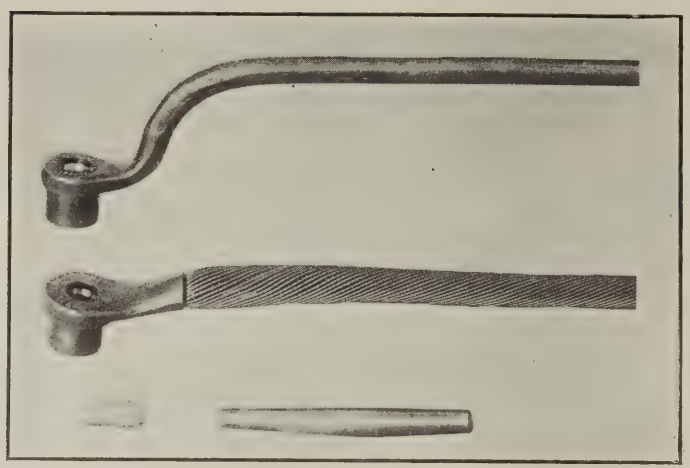
It adapts itself to mechanical stresses, and the unit design permits of economical replacements.

On the other hand, it calls for more structure height and cost, and an economic study must be made in each case before a decision as to type can be reached.

Sectionalizing of System

The sectionalizing of main line and yard tracks is governed to a large extent by operating conditions and can be determined, in detail, only after a study on the ground and consultation with the railroad operating officials.

With more than one track, the location of main line sectionalizing points are largely determined by existing or proposed track



Tubular Stud Railbonds With Taper Punch and Pin

cross over locations, particularly when employees are located at such points. This, of course, in conjunction with the nature of service. The segregation of tracks is governed by nature of service. It is fair to assume that in most cases when traffic justifies more than one track, all main line tracks should be independently insulated and switched so as to retain full operating flexibility and capacity as far as possible.

The sectionalization of yard tracks is purely an operating matter and must be determined from data furnished by railroad operating officials. The natural subdivision of most yards into storage,

Left—Direct Suspension for Street Railway Supported from Side Brackets and Welded Angle Iron on Reenforced Concrete Poles. Brackets for Feeder and Other Wires Cast with Pole
Right—Steel Poles Made of Old Track Rail, with Arc Welding Connections and Solid Concrete Poles

classification and other sections offers suggestions as to sectionalizing.

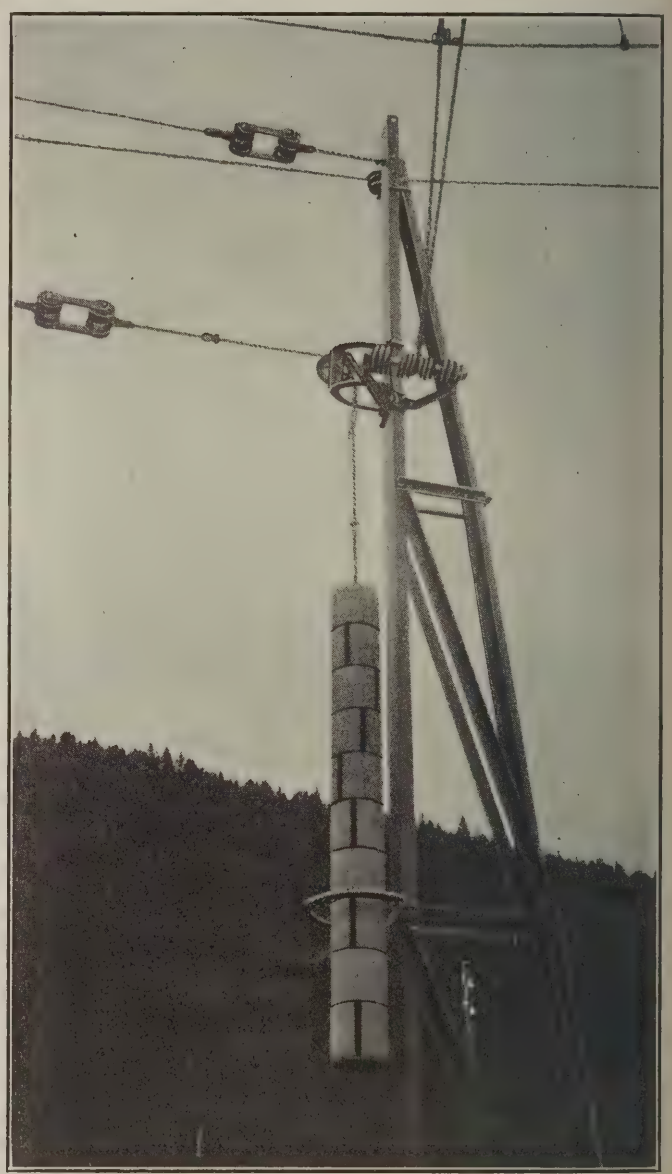
Bonding.—The principal types of rail bonds used in the United States are as follows:

1. Solid stud applied with compressor.
2. Tubular stud, expanded with pin.
3. Gas weld, applied with oxyacetylene flame.
4. Arc weld, applied with electric arc.

Type 2 has been more generally used for heavy traction work, with conductor under joint plates and terminals exposed, or conductor and terminals outside joint plates. The former is preferable on account of protection against theft and damage, but requires certain space between joint plate and rail.

Gas weld bonds have been used to a large extent on street and interurban roads, but have not been given a thoroughly conclusive trial on heavy work. They have been applied generally to the head of the rail and are from seven to eight inches long.

Arc weld bonds are being tried out on heavy work, and good



An Old Form of Counter Weight for Contact Wire Tension Adjustment. Weight Units Are Made of Concrete

results in that line are expected. It is common practice to bond both rails on main line tracks and one rail only in yards. Main line track rails, unless carrying signal current, are generally cross bonded about five times per mile. The same rule applies to bonded rails in yards. If direct current is used for traction, and alternating current for signals, cross bonding between track rails is confined to impedence bond locations which are generally determined by the signal system layout.

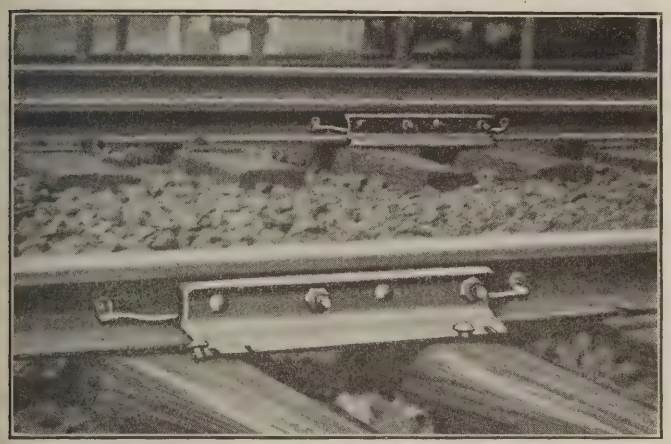
Installation of Rail Bonds.—It is probable that, generally speaking, rail bond installation has not been given the care it deserves. This applies particularly to types 1 and 2, which, on account of inherent fault, require the utmost precautions in regard to cleanliness in preparation of bond holes and bond terminal studs. The fault referred to is the lack of perfect contact between copper and steel, and the fact that even with perfectly clean copper and steel, if bond stud, after cleaning, is touched by fingers with nor-

mal amount of surface moisture, a film of oxide is formed which prevents the desired current carrying contact. At the best, a good percentage of bonds will in time depreciate as regards contact values. Furthermore, there has been much carelessness in the use of badly worn or tapered drills, and improperly sharpened drills.

When new rail is being laid it is best to have holes drilled undersize at the mill and reamed to exact size in the field.

When existing rail is bonded the work, from start to finish, should be done under the close inspection of a capable and well-paid man with suitable assistants to follow all details.

Hole drilling has been done in a number of ways. Some years ago jobs of some magnitude were bonded with ratchet drills with surprising results as to economy and quality of work. This method also appealed to the railway company from a safety stand-



Tubular Stud Rail Bond with Conductor Under Angle Bar and Terminals Exposed

point. The use of an "old man" attached to base of rail in combination with ratchet, permitted clearing rail for traffic instantly.

The standard collapsible track drill has been used with good results but requires two men and is a hazard under traffic.

On some later work compressed air, furnished by a portable gasolene-driven compressor and driving high speed drills mounted in simple and light frames, has cut the cost of drilling to what seems to be a minimum.

Of the four types mentioned, type two is the simplest to install. The only tools needed being a taper, or preliminary expanding punch and a heavy machinist's hammer.

Type 1 requires a somewhat heavy compressor and wrench.

Types 3 and 4 have the common advantage of good and permanent contact between bond and rail if installed by a competent welder.

When condition of rail joints, road bed and relative weight of rail and equipment, permit application to head of rail, the additional advantage of short length, lower cost and reduction in liability of theft, are realized. With rails in reasonably good condition, as regards corrosion, no preparation other than steel wire brushing is needed.

The modern equipment for installation of gas welded bonds is not cumbersome, though it requires the use of a light push car or the two-man hand speeder with tray. It consists of two gas tanks, light hose, torch and welding wire.

It is sometimes difficult to arrange for a satisfactory supply of gas when work is somewhat removed from the center of distribution.

Current supply for arc welded bonds on street railway work is generally taken from the trolley wire and the arc regulated with a simple and easily portable resistor set.

For high voltage work or when bonding must be done before wire is strung, the portable gas driven generator set must be employed.

It seems reasonable to assume that the welded bond will eventually become standard for heavy traction work.

Conclusions

There is at this time a widespread interest in electrification, and much work is either in the preliminary stages or in progress throughout the world.

Gratifying progress is being made in improving designs in all features of the work. Larger and more efficient generating apparatus, automatic sub-stations and improvements in locomotives are going to make the change in motive power more attractive to financial men and railroad operating officials.

The same spirit of progress is evident in connection with distribution and contact systems which are a considerable portion of the electrification cost.

Longer lived metals and better insulation, which are now being given much study, will cut down the fixed charges on this important item, and a reduction in the assumed loading conditions will cut out the cost of catenary system and supporting structures.

The general design and cost of the complete catenary and supporting system are materially affected by the assumed worst loading; that is, the simultaneous application of maximum wind velocity, maximum thickness of ice and minimum temperature.

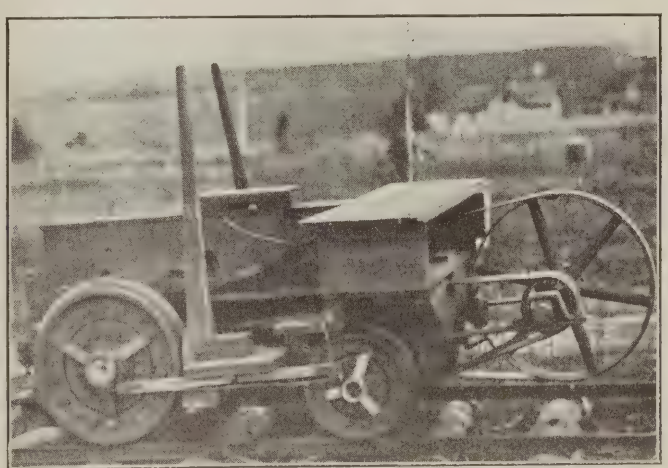
The Federal Bureau of Standards, the various states and engineering societies have made determinations on this matter, and there is a growing feeling in some quarters that the commonly accepted standards are too severe.

It is hoped by many engineers and operating people that our various standardizing agencies will see their way clear to make a reduction in such requirements with a consequent reduction in cost and a tendency towards furthering the important work of electrifying our steam railway systems.

The First Electric Locomotive*

IN THE early part of 1880 Edison decided to investigate the possibility of developing a cheap and light railroad system that would be suitable for mining operations and other industrial purposes. He was well aware of the fact that an efficient generator would also make an efficient motor, and he planned to use one of his newly developed generators as a motor for a locomotive.

An Edison A dynamo was laid in a horizontal position with the armature toward the front and its shaft parallel to the axle of the driving wheel. Upon this axle, as well as on the armature shaft, grooved friction pulleys not in mechanical contact with each other were mounted. A



The Original Electric Locomotive Presents a Decided Contrast to Those of the Present Day

pivoted lever having a third friction wheel was placed so that this wheel carried the power from the motor armature to the driving wheels when the operator pressed it.

In order to conduct the current from one rail to the motor and then to the return rail, Edison divided the car wheels into two sections and insulated these sections from one another by wood so that the hubs were not in metallic contact with the flanges. He then screwed three-legged

* Reprinted from *The Edison Monthly*.

brass spiders to the front side of the flanges so that they made electrical connection with that part only and not with the hubs. At the center of the spiders there were metal studs upon which copper brushes rested by means of which the current was taken on one side of the locomotive, while at the other side it was led back to the other rail.

Meanwhile, he had the track laid. For this Edison used light rails, about sixteen pounds to the foot—the gauge was forty inches—and they were spiked on rough ties laid on the ground in a hurried military fashion. This track ran from one side of the machine shop for a little over a third of a mile toward the ravine where the old Edison copper mine was located. Later it was extended to over a mile and included some sharp curves. The rails of this track were to serve as conductors to convey the current to the locomotive and no special precautions were taken to insulate them.

On the 13th of May, 1880, in the presence of invited guests and the whole of Menlo Park the electric locomotive was set up on the tracks. A trailer equipped with awning roof and two benches was hitched behind and as many people as could sit or find a foothold upon it crowded on.

It was a thrilling moment when the signal was given. The current was switched on, and amidst cheers, hurrahs, and the waving of hats and handkerchiefs, the locomotive began to move, then to pick up speed. When the locomotive reached the end of the road the operator applied the lever so violently that one of the friction wheels burst into four pieces. Thus ended the experiment.

In order to continue his study without delay Edison had the locomotive repaired temporarily with leather belts. A pulley on the armature shaft was connected by a belt to a larger one that was mounted on a counter-shaft at the rear of the engine. This counter-shaft had a second and smaller pulley that was belted on to the one on the driving wheels by the means of a slack belt. This, however, could be tightened by a lever arrangement and pulley such as was used in the first experiment, and thus the operator could regulate his speed. Two large wooden levers served as brakes.

What is particularly interesting, in connection with the trials is the fact that Edison inserted for starting an adjustable resistance in circuit with the armature and as he did not have room enough to conceal the whole of the resistance under the seat used by the operator he wound a part of it on one of the magnet legs of the motor. He immediately discovered the beneficial effects in starting that these extra windings produced—he had compounded a motor that before was only shunt wound. This was the first locomotive that was ever compounded and this principle forms today one of the essential features in electric railroad engineering. Also in this same year he invented the magnetic brakes for cars and the third rail system which is now universally used.

In 1882 Edison invented a system by which all the cars on a train had individual motors but were controlled by means of one controller operated in the front car. And in this same year his prolific mind invented the slotted tube surface system that eliminates the unsightly trolleys and wires.

It was only due to lack of time that Edison could not follow his inclination to devote his whole energies to the working out of all these problems, but at that critical period he was too much occupied with his first electric central station work. And yet what he did places him in the history of electric locomotion, as the foremost American pioneer of that art.

Electric Pumping Plant on the C. & N. W.

Notable Economies Effected by Substituting Electric Operation for Steam Driven Equipment

By Joseph A. Andreucetti
Assistant Electrical Engineer, Chicago & North Western

AT Clinton, Iowa, the Chicago & North Western railroad has been able to show remarkable economies in operation of an electric pumping station which superseded one driven by steam power.

The steam plant which was replaced was comprised of two 14 x 10 x 12 duplicate steam pumps, one 25 hp. and one 35 hp. locomotive boiler. With this equipment water was furnished to the engine terminal, the water being pumped from a reservoir which was supplied by gravity feed from the Mississippi river.

The water is lifted from the reservoir and pumped to two standard water tanks at the roundhouse 5,500 ft. distant through a 14 in. discharge pipe, the total head being equal to 88 ft. The amount of water consumed in a 24-hour period is 500,000 gals.

On account of this being a division point any interruption in the water supply is vital and the continuity of service is therefore very important. The average monthly cost of operation with the steam equipment before the change was made is as follows:

Coal delivered at plant per month	$430
Oil and waste per month	8
Maintenance of Equipment	200
Wages and three pumpers	311
Total	$949

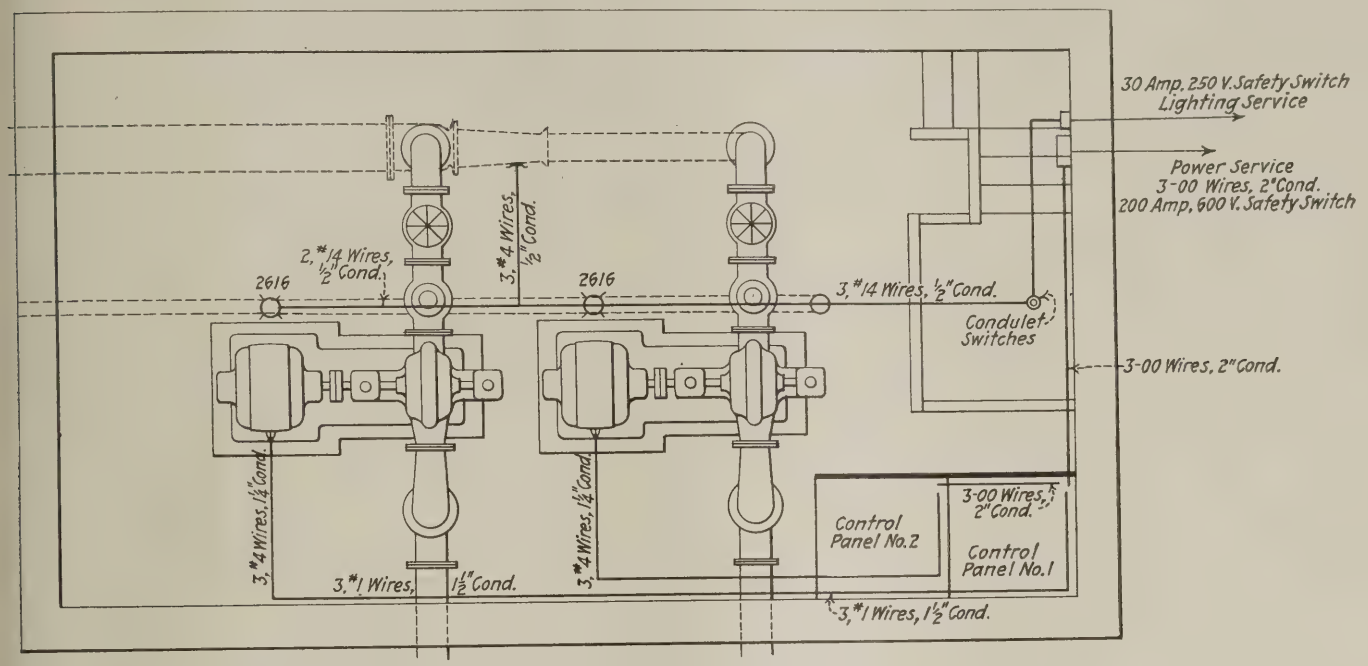
The foregoing equipment was replaced with two 1,200 gal. per minute centrifugal pumps, each operated with a 40 hp., 3-phase, 60-cycle motor, controlled with an automatic starting and stopping panel, one panel being used for each motor. The controlled panels are operated by pressure regulation.

While one pump and one motor are sufficient to supply the water service, duplicate equipment was installed to safeguard against failure on account of the importance of this station. In regular service the pumps are used alternately a week at a time.

The cost of operation and maintenance with the electrical equipment is as follows:

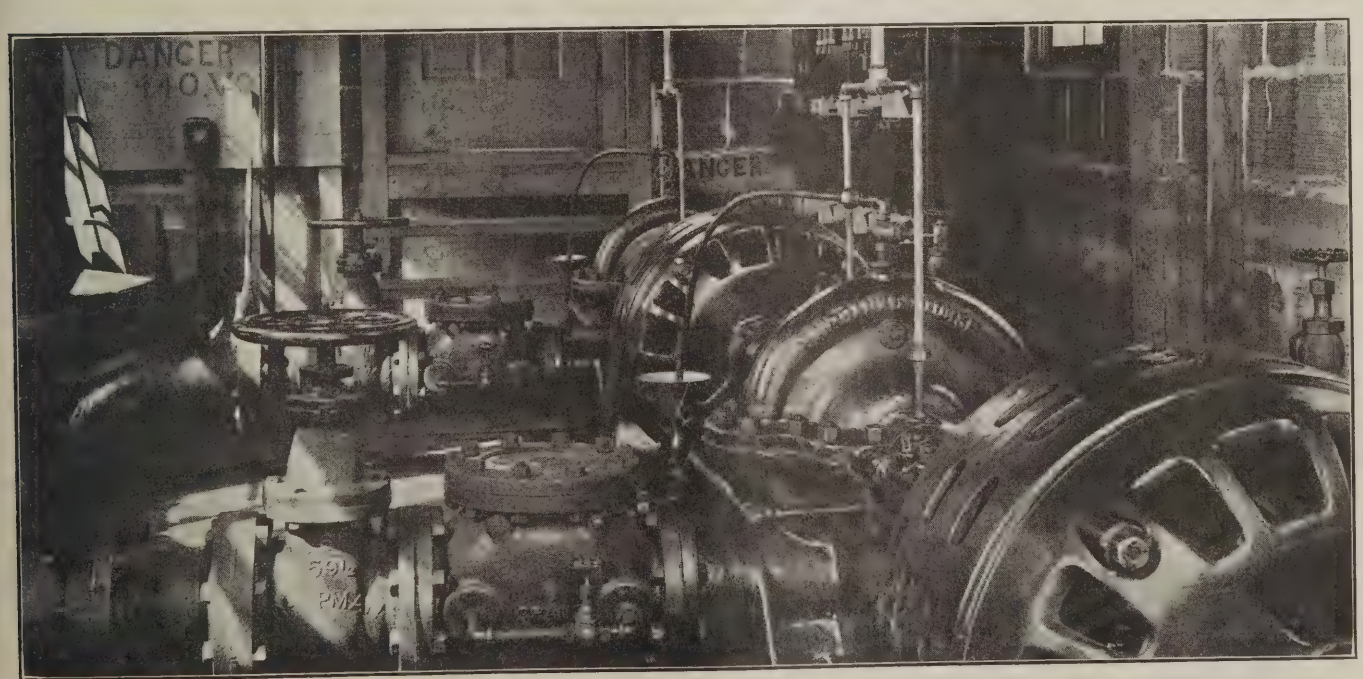
Current per month	$310
Labor and supplies	65
Total per month	$375

It will therefore be noted that the savings effected by the change is $574 per month. The total cost of the new installation, including the building, very closely approximates $6,000.


30 Amp. 250 V. Safety Switch Lighting Service
Power Service 3-00 Wires, 2" Cond. 200 Amp. 600 V. Safety Switch
2, #4 Wires, ½" Cond.
3, #4 Wires, ½" Cond.
2616
2616
3, #14 Wires, ½" Cond.
Conduleт Switches
3-00 Wires, 2" Cond.
3, #4 Wires, ¼" Cond.
3, #4 Wires, ¼" Cond.
3, #1 Wires, 1½" Cond.
Control Panel No. 2
3-00 Wires, 2" Cond.
Control Panel No. 1
3, #1 Wires, 1½" Cond.

Plan Drawing Showing Location of Pumps, Motors, Switch Boards and Piping

The writer is of the opinion that there is much work of this kind to be done on steam railways and that electrical engineers or those in charge of electrical departments can put in their time to no better advantage than in ferreting out these cases and working up data showing economies which the management can act upon. If this is done the savings effected by the additional use of electrical apparatus will show an astounding increase in a remarkably short time.



Interior of Electric Pumping Station at Clinton, Iowa

General News Section

The Economy Fuse & Manufacturing Company, Chicago, has removed its Minneapolis district sales office to 1008 Marquette avenue, Minneapolis, Minn.

The Ohio Brass Company, Mansfield, Ohio, has moved its Philadelphia, Pa., office from the Witherspoon building to 1404 Packard building at Fifteenth and Chestnut streets.

Frank A. Wilch, of the Triumph Electric Company, Cincinnati, Ohio, who has been associated with the Cleveland office, has been placed in charge of that territory. He succeeds Edward S. Ford.

The Interstate Commerce Commission has denied the petition of the Chicago, St. Paul, Minneapolis & Omaha for exemption from the train control orders of June 13, 1922, and January 14, 1924.

An increase of $37,676 000 in the sales of the Western Electric Company is reported for the first eight months of 1924 during which the billings reached a total of $195,-167,000. Orders received during the first eight months of this year totalled $198,892,000 or $7,566,000 more than the orders received during the same period of 1923.

The Interstate Commerce Commission has granted the petition of the Baltimore & Ohio for a modification of the train control order of January 14, 1924, so as to permit it to install automatic train control upon the passenger division between Baltimore, Md., and Philadelphia, Pa., in lieu of the installation required in the order.

The Electric Arc Cutting and Welding Company of Newark, N. J., has appointed H. D. Rohman of the R. C. S. Equipment Company, 8 East 41st street, New York, as its agent for the sale of "Taperod" electrodes. In addition, Mr. Rohman will endeavor to interest railroads in the use of "Alternarc" transformer, welding equipment and "Newarc" accessories and supplies.

A "Country Fair" is being held by the Railroad Y. M. C. A. at Pennsylvania Station, New York City. The Long Island Railroad, a part of the Pennsylvania system, has a large demonstration farm at Medford, Long Island, and products from this farm, in the custody of H. B. Fullerton, director of agricultural development, form a chief feature of the fair.

Painting Edison Storage Batteries

In the August, 1924, issue of the Railway Electrical Engineer, page 252, an article was published entitled, "Maintaining Edison Car Lighting Batteries."

Under the head "Painting," a statement was made to the effect that the Union Pacific makes a practice of painting Edison storage battery trays approximately every three months, depending upon how and where the battery is used and upon the location of the car which contains the battery at the time when the battery is scheduled for repainting. The trays are painted every sixteen months rather than every three months, except on occasions when repainting is done in a shorter period, due to the fact that the car containing the batteries is shopped before the 16-month period expires.

Chicago-St. Louis Speed Competition

The competition for passenger traffic between Chicago and St. Louis has become so keen that three roads have cut their fastest schedules to 6½ hours and have placed in service new cars embracing a number of innovations. Following the action of the Chicago & Alton with the Alton Limited, the Illinois Central reduced the time of its Daylight Special to 6½ hours or 1¼ hours below the old schedule. The train now leaves Chicago at 11:45 a. m. and arrives at St. Louis at 6:15 p. m. On the same day a new all-steel train was put on to leave Chicago at 9 a. m. and arrive at St. Louis at 4:43 p. m. The equipment of the Daylight Special includes parlor cars, dining car, chair cars and coaches. With the announcement of the Illinois Central, the Chicago & Alton changed the effective date of its new schedule to September 23. Following this the Wabash announced the installation of new all-steel cars on its Banner Limited and reduced its schedule to 6½ hours, effective September 21. Under the new schedule this train leaves Chicago at 11:30 a. m. and arrives at St. Louis at 6:15 p. m. The equipment consists of observation-parlor car, vestibule-parlor car, dining car, reclining chair car and smoking car. The action of the Wabash caused the other roads to put their schedules into effect on September 21.

Westinghouse Receives $1,000,000 Order

The Westinghouse Electric & Mfg. Co. announces the receipt of orders totalling approximately one million dollars for apparatus to be used in connection with the ten-million-dollar improvements which the Baltimore & Ohio Railroad is carrying out on Staten Island in electrifying the Tottenville and South Beach branches of its subsidiary, the Staten Island Rapid Transit Co.

The Westinghouse contracts cover five automatic substations with supervisory control for the Staten Island Rapid Transit Co., and high-voltage equipment for the Staten Island Edison Corporation, which will supply the power for operating the railway.

The automatic, supervisory-controlled substations which will receive high-voltage current from the power house and transform it into low-voltage current for the railway, represent one of the most modern developments of electrical engineering, and are probably the most nearly human of mechanisms ever devised.

Four of these stations will have no attendants whatever,

and the fifth will be the central control station for the whole system. All of the processes of a normal character, such as increasing or decreasing the power supply in response to the demands of the railway, will be carried out automatically by the stations. Machinery will start up and shut down, switches will open and close, and other operations, sometimes of the greatest complexity, will take place without human intervention. Inasmuch as this machinery can act several times more rapidly than can the most experienced operator, and cannot make errors in connections or sequences, it provides maximum reliability of operation. Should anything go wrong, everything is instantly shut down.

In addition, each station will be under the direct and complete control of the power load dispatcher located at the central control station. This is the purpose of the supervisory control system. By means of this system the dispatcher can ask any station for information in regard to any detail of operating conditions, such as the load on a machine, the position of a certain switch, or the temperature of any one of the bearings. The information desired is promptly given him automatically by the station questioned, and he can then, by pressing the proper button, make any change at the station that circumstances may require.

Each of four of the substations will contain two 1,000-kilowatt rotary convertors with the necessary auxiliary apparatus, and the fifth will contain a single convertor of the same size. The current to be supplied to the railway will be the same as that used for operating the subways of Brooklyn and Manhattan.

A Whole Day of Automatic Train Control

At the fifteenth meeting of the Signal section of the American Railway Association, held at the New Ocean House, Swampscott, Mass., on September 23, 24 and 25, the second day, Wednesday, was set aside for the discussion of the subject of automatic train control. The session started at 8 a. m., eastern time. All papers were limited to 20 minutes. The program was divided into three parts, the first covering tests conducted on the Pennsylvania, the Atchison, Topeka & Santa Fe, the Union Pacific, the New York Central, and the Southern Pacific. The second part covered the relation of air brakes to train control and included an analysis of accident records. The third covered installations now in service on the Chicago & Eastern Illinois, the Chesapeake & Ohio, and the Chicago, Rock Island & Pacific. Following the presentation of the subject matter above referred to, there were five-minute discussions of the subject of train control by representatives of train control companies.

Further Electrification on the New Haven

The New York, New Haven & Hartford announces that work has begun on the preparation, for electric operation of its line from South Norwalk, Conn., northward to Danbury, 24 miles, and on the Ridgefield branch, 4 miles. When this change is made the complete electrification of the New York division will have been finished. Six passenger trains a day are operated over the Danbury line southward and seven northward, and there is a considerable freight traffic.

It is hoped to complete the improvement by January next. It is expected to secure substantial economies in the utilization of electric locomotives.

Great Northern to Electrify 80 Miles

The Great Northern will soon begin to prepare for electric propulsion on an 80-mile section of its line over the summit of the Cascade mountains, according to an announcement by L. C. Gilman, vice-president, at Seattle, Wash. The line between Wenatchee, Wash., and Skykomish will be the first to be electrified. Power will be furnished by the company's power plant, to be installed on the Chelan river. The site has already been purchased and plans have been made to construct a generating station capable of supplying power for the entire electrified line.

Plans for the electrification of the line between Spokane and Seattle were made before the war, but construction at that time was postponed because of the high cost of labor and materials. With the return of more normal conditions, the work is to be pushed to completion.

Personals

Edward H. De Groot, Jr., heretofore assistant director of the Bureau of Service, has been appointed director of the Bureau of Signals and Train Control Devices, which supersedes the section of signals and automatic train control in the Bureau of Safety of the Interstate Commerce Commission. Mr. De Groot has been in general charge of work, without change in title, for several weeks. Mr. De Groot was born March 22, 1871, at Galesburg, Ill., and until he went to the Interstate Commerce Commission in 1917, had been in railroad service, having begun on May 13, 1886, as office boy in the general freight department of the Chicago, Burlington & Quincy. After holding various positions in the office, train and yard service of the Burlington and the Chicago & Eastern Illinois, he became train master of the latter road in 1902, and later successively division superintendent, superintendent and track supervisor, superintendent of the St. Louis division and terminals, and superintendent of transportation. In July, 1917, he was appointed chief of the Division of Car Service of the Interstate Commerce Commission. In 1918, after the government took over the roads, he was appointed assistant manager of the Car Service Section of the Railroad Administration. In January, 1919, he was appointed assistant director of the Division of Operation of the Railroad Administration and in June, 1920, he was appointed assistant director of the Bureau of Service of the Interstate Commerce Commission.

E. H. De Groot, Jr.

Major J. L. Hays has joined the railway department of the Edison Storage Battery Company with office at 1419 G street N. W., Washington, D. C. Major Hays was a graduate in electrical engineering of Lehigh University in 1909. After completing his school training he joined the electrical department of the Baltimore & Ohio. He worked there successfully as a mechanic, draftsman, instructor, general foreman and assistant engineer. He was later appointed electrical engineer of the Seaboard Air Line and served in this capacity until he was commissioned as major in the Quartermaster's Corps at the beginning of the war, in charge of the electrical section of the engineering branch, being responsible for electrical construction for the army in the United States. At the conclusion of the war he joined the Stone-Franklin Company as electrical engineer. The car lighting interests of the Stone-Franklin Company were absorbed by the Safety Car Heating & Lighting Company on January 1, 1923. Major Hays joined the field organization of the Safety Car Heating & Lighting Company and served that company in the capacity of sales engineer up to the time of his making his present affiliation with the Edison Storage Battery Company.

Major J. L. Hays

E. R. Chinberg, electrical supervisor of the Chicago Rock Island & Pacific, has resigned to take the management of the West Gate Welding & Electric Supply Company, of San Francisco, California, a newly organized company dealing in electric welding apparatus and supplies. The statement announcing Mr. Chinberg's appointment which appeared in the September issue of the *Railway Electrical Engineer* was incorrect. Mr. Chinberg has the California distribution of the complete line of U. S. L. electric arc welders manufactured by the U. S. Light & Heat Corporation, Niagara Falls; the Western distribution of the Wanamaker coated electrodes, manufactured by the International Welding Engineering Corporation, Chicago, Illinois, and the Tecor welding accessories manufactured by the Transportation Engineering Corporation of New York City. Mr. Chinberg began his electrical and welding career in 1907 when he entered the employ of the Goodland Light & Power Company, Goodland, Kansas. He began his services with the Chicago, Rock Island & Pacific Railway in 1910, and through successive promotions was appointed electrical supervisor in 1917. He was associated with Mr. Wanamaker, electrical engineer in the electrical and electric welding development on that railroad until last April, when he resigned to take over his new duties. The office of the newly organized company is at 18 Front street, San Francisco, California.

E. R. Chinberg

Trade Publications

Central Electric Company, Chicago, Illinois, has recently issued its new catalogue No. 40. This issue, which supersedes all of the company's previous catalogues, contains 804 pages. It is arranged in a convenient form for easy and quick reference.

Mica Insulator Company, New York, has recently published a small illustrated booklet entitled "Commutator, Insulation and Assembly." The pamphlet describes the handling of mica from the mine to the finished product as it is used in commutator construction.

The Sangamo Electric Company of Springfield, Ill., has recently published a small illustrative pamphlet on Sangamo amperehour meters for train lighting systems. Various amperehour meters which meet the different conditions of operation are illustrated and described.

Voltage Tester.—A folder has recently been issued by the Square D Company, Detroit, Michigan, describing a device known as the Wigginton Voltage Tester. It is a small device for use by electricians for measuring the voltage on either alternating or direct current circuits of from 110 to 550 volts.

Insulating Varnishes and Compounds, a 24-page booklet describing and stating the application of various varnishes, insulating compounds and finishing materials, has been recently issued by the Westinghouse Electric and Manufacturing Company. The booklet, which is known as Folder 4249B, contains complete information for the user of insulating materials in these classifications and has been designed as a book for ready reference in the selection of such material.

A new publication entitled "Electrical Equipment for Railroad Shops," is being distributed by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. This new publication, known as C-1661, is intended to assist engineers in solving the electrical problems frequently encountered in increasing shop facilities or changing or adding to existing equipment. It contains pertinent information and general principles, serving as a guide in the selection of electrical equipment for engine and car shops, engine terminals, freight terminals and passenger stations. The results of the application of individual motor drive and the extensive use made of magnetic control, both automatic and semi-automatic, in railway shops are described in detail and by illustrations. A description of the arc welding process and its uses in track reclamation, general track repair work, together with valuable machine tool data, are included within its pages.

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Unique Purchasing Methods

Many methods have been devised for marketing merchandise in various fields, but it is doubtful if anything more unique has ever been tried by railroad supply manufacturers than the plan by which one railroad was enabled to purchase the equipment which it needed badly without spending any of its own money. The manufacturer who has such confidence in his product that he is willing to sell it on condition that it must show savings to its purchaser before he receives any payment for the equipment, certainly deserves to succeed. To pay for equipment out of the saving which it effects may not be an original idea, but it certainly is an unusual method in the railway supply field. When welding machines were required on a certain road, the management was told that the machines would be furnished by the manufacturers and that the roads could pay for them out of the saving which they brought about, and furthermore, that the management should say what the saving was. This remarkable stroke of salesmanship, which was not only profitable to the railroad but to the manufacturer as well, is more fully explained on page 377 of this issue. When a road is able to show a saving of $50,000. a year without making any capital expenditure for equipment, it would seem that perhaps there was something in the method which could well be adopted by other roads and other manufacturers. Sometimes it requires unusual methods to bring about the installation of equipment, but in this case at least it must be admitted that the end justified the means and has paid handsome dividends on the venture.

Train Radio to Increase Traffic

The development of radio receiving sets has progressed to a point where it is entirely practicable to use them on moving trains and be assured of successful operation. This, of course, does not mean that further improvements will not be forthcoming, but it does mean that the art has advanced far enough so that the application for receiving sets to certain through trains might well be given serious consideration. Numerous tests have been made under many varied conditions and the results obtained have been, for the most part, very successful. With the large number of broadcasting stations which are on the air a great portion of the time, it is quite possible to bring radio programs into the cars almost continually if desired. While it is true that a certain number of passengers will not be interested in the reception of such entertainment, it is equally true that a very large number are interested and there is little doubt that if installations were made they would be used a great deal. People who travel extensively and are on trains for long periods of time are generally in the mood to welcome almost any kind of diversion and it is reasonably certain that a large number of these would be glad to make use of radio equipment if it were provided. Just what method would be most suitable to use in applying radio receiving sets to moving trains is something for study and experiment, but it does not require a great amount of foresight to see that it might be the means of making certain through trains popular and thereby increasing the passenger traffic upon them. It is a matter which the electrical engineer can scarcely afford to ignore entirely even though it may not seem to be a question of urgent importance at the present moment.

The Growth of the Industry

Fifty-seven manufacturers and distributors exhibited their products at the fifteenth annual convention of the Association of Railway Electrical Engineers which was held in the La Salle hotel in Chicago, October 21 to 24. A year ago at the same convention there were 39 exhibitors. In 1923 the exhibits occupied 4,600 square feet of floor space. This year it was 6,000 feet and the exhibit committee could have sold 25 per cent more space if they had had it to offer. The exhibits were not only larger than they have ever been before, but they were more elaborate in character. Instead of the static display of manufactured products which characterized the exhibits in years past, many of the machines and devices were shown in operation. The greater amount of space which some of the exhibitors were able to obtain was used to good advantage in making attractive displays.

For the first time in the history of the Association one type of train control apparatus was included among the exhibits. Full size equipment was shown in operation. This manufacturer is as yet apparently the only one able to appreciate the fact that if his device is to enjoy successful operation on any railroad the electrical men in the mechanical department must be familiar with its characteristics and possibilities. Another new exhibitor similarly appreciative of the railroad market showed fire alarm equipment in operation. The other 17 new exhibitors show car lighting fixtures, electric hand lanterns, crossing signals, direct and alternating current motors, conduit, conduit fittings, fuses, commutator repair equipment, blowers for cleaning electrical machinery, roller bearings, car lighting pulleys, wire and cable, welding equipment,

outdoor lighting units, disconnecting switches, insulators, rectifiers, electric trucks, electric heaters and heat regulators, ball bearings, safety switches and electrical instruments. Only one exhibit shown in 1923 was omitted in 1924 and this is a subsidiary of a company which exhibited both years. Many new and improved devices were shown by the older exhibitors. Most of these have been or will be described in the "New Devices" section of the *Railway Electrical Engineer.*

The most significant thing about the exhibits is that they constitute a tangible picture of the ramifications of the electrical industry as applied to the steam railroads and show also the nature and extent of its rapid growth. The time has arrived when few if any of the principal electrical manufacturers can afford to disassociate themselves from this branch of their industry.

Motor-Generator Locomotives

Announcement was made some time ago in these pages of the motor-generator type electric locomotives which will be used on the Detroit & Ironton. The mechanical parts were designed and built by the Ford Company and the electrical machinery was built by the Westinghouse Electric Manufacturing Company. These locomotives are now being assembled in the Highland Park Ford Plant at Detroit, Mich. Announcement has also been made that the New York, New Haven & Hartford has ordered seven motor generator type electric locomotives which will be built by the General Electric Company and the American Locomotive Company.

The outstanding disadvantage of this type of locomotive is that it must "carry its substation about on its back" and that each one of these portable substations must be big enough to provide full load current for the traction motors. When the substations are stationary and are located along the right of way the substation capacity does not have to be as great as the connected locomotive load as more than one substation can supply power to a locomotive and in cases where a number of locomotives work in one district, all of them seldom if ever, require full load current simultaneously. Balanced against these factors are the advantages offered by the fact that this type of locomotive can use a high voltage alternating current trolley, the direct current motors used have characteristics which are best for traction purposes and the control apparatus is extremely simple and effective.

Almost since the beginning, the argument concerning the relative merits of alternating and direct current for traction purposes—the battle of the systems—has retarded the adoption of electric traction by the railroads. As long as the traction experts failed to reach a decision as to which system was best, it could hardly be expected that the railroads would be enthuiastic purchasers of something that represented so large an expenditure. It should not be inferred by this that the motor-generator locomotive is the direct answer to the problem. They are looked upon by some critics as a compromise, but they may be much more than that; they may actually prove to be so successful that they will be used extensively. In any case they indicate that the hatchet has been buried; the battle of the systems has to be relegated to the scrap heap. These locomotives split the chain of power between the power house and the locomotive drivers in a new place and they bring alternating and direct current together on the same locomotive. They possess highly desirable qualities which are inherent to this type and it is highly possible that the study of these locomotives which will follow after they have been placed in service will be an important step in putting electric traction where it ought to be in the railroad field.

Welding Steel Structures

The welding of fabricated steel structures, which practice would supplant the use of rivets, is a topic which is now bidding for the attention of welding engineers. Electric welding and electric power supply will undoubtedly be an important factor in this new line of endeavor. The subject was introduced formally for the consideration of structural engineers by the American Welding Society at its annual fall meeting held in Cleveland, Ohio, on October 30 and 31. It was apparent at this meeting that welders in general know very little about the fabrication of steel buildings, but structural engineers are evidently interested in the possibilities offered by welding as several of them attended the meeting and took an active part in the discussion.

The welders estimate that a welded structure can be made equal in strength to a riveted structure with a saving of from 15 to 25 per cent of the metal used. Lee H. Miller, American Institute of Steel Construction pointed out the fact that 3,000,000 tons of structural steel are used each year in the United States and Canada. He said structural engineers want to know how to reduce costs, J. H. Edwards, American Bridge Company said that the optimism shown by the welders is both necessary and desirable. He prophesied that the first large application of welding to structural work would be made on jobs in which there is a considerable duplication of operations which can be performed with the aid of jigs. If Mr. Edwards is right, spot welding will play an important part in the introduction of a practice that means a saving to steel constructors and a tremendous increase in the use of welding apparatus.

The welding engineers described in detail some of the structures which have already been fabricated by welding. These for the most part are relatively small buildings. The gas welders advocated the use of pipe for structural members stating that a pipe or tube has the greatest strength for its weight of any structural form. They stated that existing structural shapes or sections are not suitable to welding and that new shapes should be developed. The electric arc welders while expressing a desire for better structural shapes, showed trusses and other pieces of construction built of standard sections with electric arc welding. The difference of opinion between the gas and electric welders is apparently due to the fact that the electric arc process when applied to channels, angles, T bars, etc., does not warp the members as the gas flame does when the welding is being done.

These facts make it appear that electric arc welding and electric spot welding will be largely instrumental in introducing fusion welding in the structural field. This will in time greatly enlarge the scope of welding and it will at the same time introduce a problem in power supply that will require the attention of the electrical engineer. Electric welding in building construction will require numbers of relatively large portable electric machines.

Electrical Men Hold Big Convention in Chicago

New Attendance Records Established at Best Series of Meetings the A.R.E.E. Has Ever Had

THE Fifteenth Annual Convention of the Association of Railway Electrical Engineers held in the Hotel La Salle, Chicago, Oct. 21 to 24, was unquestionably the biggest and the best convention that the association ever held. The average attendance at the four sessions was very close to 200 and the discussion of the various reports presented was carried on with such enthusiasm that on three out of the four days of the convention it was necessary to hold informal round table meetings in the afternoon at which time it was possible to continue the discussions on the more urgent subjects. This step marks an innovation at the conventions and indicates the constantly increasing importance of the electrical engineer's work.

In previous years the nineteenth floor of the hotel has been sufficient space both to hold the meetings and to house the exhibits which the Railway Electrical Supply Manufacturers' Association show at this time, about half the space being devoted to exhibits. This year, however, the entire nineteenth floor was required for exhibition space, while the convention sessions were held in the East room on the mezzanine floor.

The convention was formally opened on Tuesday, October 21, at 10 a. m. by the president, E. Lunn, electrical engineer of the Pullman Co. In presenting his opening address Mr. Lunn spoke in part as follows:

"Gentlemen and fellow members of the Association of Railway Electrical Engineers: It is with pleasure and a feeling of assurance that in behalf of the officers of this association, I bid you welcome to the Fifteenth Annual Convention. We have no misgivings as to whether you will hear or see things of interest to you during the session in this room and while inspecting the exhibits. As an index of interest taken in the affairs of this organization space in the exhibit room, although almost double what it has ever been in years past, is at a premium. There is a valuable lesson in this greater activity so definitely indicated. The association, by virtue of the earnest and untiring efforts of those who have had its affairs in charge during the fifteen years of its existence, has taken its rightful place as a nationally known and well thought of organization, the proceedings of which hold the attention, not only of engineers, but of many others including railway officers.

"The high standards established must be maintained in whatever is undertaken. It is expected of us. The reports which will be presented are to the point and challenge your criticism. They now belong to you as much as to those who prepared them—yours to adopt or amend. Those who are not serving on committees as well as those who are, are expected to voice their sentiments regarding the subjects covered in the reports and to bring up new matters for consideration. The exhibits as you have undoubtedly already noted are exceptionally fine and well worthy of careful inspection. The splendid opportunity afforded to become better acquainted with the manufacturers' representatives should not be passed up. To be acquainted with the salesman or engineer, who may later call upon you, often serves to bridge over the gap of uncertainity and doubt which frequently stands in the way on matters which, if each understood the other's point of view, could be handled to mutual advantage.

Hotel La Salle, Chicago

"We are under obligation to the various committees and gratefully acknowledge the debt for the care and thoroughness with which they have prepared their reports. Some of the reports have entailed an endless amount of investigation and search for facts which take up relatively small space when ready for the printer. Our thanks are also gratefully extended to the manufacturers' representatives for their valuable assistance in behalf of this association."

Immediately following the president's address the report of the secretary-treasurer, J. A. Andreucetti, was presented which showed the sound financial standing of the organization, there being nearly four thousand dollars on hand.

Under the head of new business, Mr. Andreucetti introduced the subject of compiling a new manual and spoke as follows:

"We wish to take up the proposition of compiling and

issuing a looseleaf manual to contain recommended and adopted practices of the association. The purpose shall be to appoint a Committee to go back into the past proceedings and records of the association and take therefrom data having to do with recommended practice and standards and embody them into a looseleaf manual form independent of the proceedings. We are behind in that respect. Other organizations have long since adopted that. The American Railroad Association in its various branches have looseleaf manuals. We will require the co-operation, of course, of every one in this work, especially the manufacturers, and I rise today to make a motion that a committee be appointed to go into this matter, the committee to be appointed by the Executive Board, and that that committee have available for the June meeting a report on what can be done along those lines, and if it is at all possible and if the association can finance it, to be empowered to go ahead and complete the looseleaf manual so as to have it ready by this time next year."

E. H. Hagensick (U. P.): "I second the motion."

The Secretary: "I feel if the Association can get the looseleaf manual up, I do not know whether they can, and can put it into effect that it will serve our needs for several years."

The President: "You have heard the motion. All those in favor say Aye. Those opposed No. It is carried."

In the following pages are given abstracts from the discussion concerning the reports presented. The only technical report presented at the first session was that of the committee on Insulated Wires and Cables. This was presented by F. J. White who said in part:

"Since the last meeting, Committee No. 4 on Rubber Insulated Wires and Cables have finally presented the four specifications I referred to in my last report. They have been passed upon by the Executive Committee as being correct as to form and scope and within a month or six weeks they will be presented to the Sectional Committee for a vote. The four specifications are a specification for code rubber, a specification for thirty per cent Hevea, a specification for thirty per cent Para, which is similar to the signal specification, and a specification for forty per cent Hevea rubber. Several other committees have informed me recently that they are practically ready to submit final specifications so at the next meeting of the Sectional Committee they should not only have these rubber specifications submitted to them but several others as well."

The President: "Are there any remarks in regard to Mr. White's report? If not, a motion to accept the report and continue Mr. White as Chairman of the Committee will be in order."

L. D. Moore (M. P.): "I make that motion, Mr. Chairman."

A. E. Voigt (St. Fe.): "I second the motion."

The President: "You have heard the motion. Are there any remarks? All those in favor say Aye. Those opposed say No. It is carried."

WEDNESDAY SESSION

Economics of Electrical Appliances

The first report presented on Wednesday morning was that of the committee on the Economics of Electrical Appliances. In connection with this report, E. A. Lundy of the E. A. Lundy Company said:

"There is an article in this issue of the *Railway Electrical Engineer* on a pumping station on the Northwestern. It has been outlined by Mr. Andreucetti in an excellent way, showing what has been done and how it has been done. You can go over pretty nearly every railroad in the country and find hundreds of similar cases.

"In connection with the preparation of reports, a lot of us have the fault in getting a report together too elaborate on all details. A certain particular job fell flat when presented to the management but later on when boiled down and put before the busy man in such shape that he could read it, it was put through in half an hour."

The President: "I would like to know to what extent electrical men as a rule concern themselves with questions of this kind in the preparation of reports. I sometimes think that too many of us are prone to wait until some one else makes a recommendation and then we step in and either approve it or object to it. Do we go out and hunt for things like we should? Are we active enough in our own organizations in visualizing what could be done if we made such and such a recommendation and got it approved? For instance, in looking over the various subjects here like pumping stations and electric welding and various things in connection with locomotive shops, I know from my own experience I have been surprised to find that here was a problem that needed solving, and I had not seen it until some workman recommended it. Then I found to my surprise it was a good thing and I approved it. I may be alone in that respect. Maybe the rest of you are more keen than I am, but I find every day some things I have overlooked."

A. M. Frazee (D. M. & N.): "I would like to say it has been my experience that it takes as much care and thought in preparing your problem to present to the operating official so that he will appreciate it, as it does to figure out the necessary engineering and economic features in the project itself."

Mr. Bebout (C. & O.): "I find on some roads the electrical department is something on the order of a necessary evil. It exists because it is there and they don't pay much attention to the electrical man. I also find that that is largely due to the attitude of the men themselves. They are not aggressive. They do not get out and push for what belongs to them. A man that does not take in everything on his road that belongs to him is not going to accomplish very much. If he waits for the other fellow to check up the things he ought to handle he is going to be left behind. There is not anything on my road in the electrical end that does not come under my handling. I am going after it and if I cannot handle it I will get somebody else to help out. I think every man should go after all that is in his department. He should handle his department entirely."

A. J. Farrelly (C. & N. W.): "Mr. President, I want to say a word in regard to the necessary evil. I was told personally by a general manager of our road that the electrical department was a necessary evil. Now that was some years ago. Since that time the conditions have improved. The present general manager called me to the office some time ago in regard to the advisability of buying or making power at certain points. I told him it would have to be looked into and he said: 'Who is the man to tell me about that?' I said, 'I guess I am.' He said, 'Get busy'.

"I would like to ask a question, Mr. President. In

pumping about how much water is allowed per kilowatt on an average? I want to see whether I am anywhere near right or not."

MR. MILLER (C. & O.): "On two or three tests which I have had the pleasure of conducting I find we are getting about fifteen to eighteen hundred gallons to the kilowatt, which is using a Fairbanks-Morse centrifugal pump."

MR. BEBOUT: "There is one thing that you do not want to overlook when you are estimating gas or oil engines against electric drives, and that is the maintenance. Several years ago I was getting chesty about what a wonderful record I was making with a big gas engine producing power at something less than three-quarters of a cent with interest, depreciation and everything included. One morning I walked into the plant and the chief engineer says, 'There you are.' It cost something over $5,000 to make the repairs. When you figure on gas and oil engines you have got to figure on high maintenance costs."

MR. SHIRK (C. G. W.): "In this matter, there is not an installation that goes in but what they do not refer it to me. In nearly all cases the oil pump is the cheaper. We must take into consideration in pumping water the dependability of the water supply. In a great many locations the local electric companies or power lines are on a single phase line and their service is not an uninterrupted service. They have lots of interruptions. That is one factor that you will have to investigate very closely. In all cases that we have investigated and gone into the matter very, very thoroughly we can pump water with a Y engine from two or three cents a thousand gallons cheaper than we can with current rates for electricity. That takes in stations up to a daily consumption of 2,000,000 gallons."

J. L. MINICK (Pennsylvania): "Mr. Chairman, I would just like to call your attention to one thing in the use of gasoline and oil pumps or oil driven machinery. Some of the states are requiring the equipment to be operated by a licensed engineer which means of course considerable expense for your engineer. I am giving you the information because some of the men may not be familiar with that and it is an item that ought to be given very serious consideration in laying out a plant of that kind."

MR. PRESIDENT: "Mr. Lundy, I will ask you to close the discussion if you haven't anything further to say."

MR. LUNDY: "I think we have covered all we have in mind, Mr. President."

THE PRESIDENT: "A motion to accept the report and continue the Committee then will be in order."

MR. MOORE: "I move the report be accepted and the Committee continued."

MR. HAGENSICK (U. P.); "I second the motion."

THE PRESIDENT: "You have heard the motion. Are there any remarks? Those in favor say Aye. Those opposed say No. It is carried."

Power Trucks and Tractors

L. D. Moore of the Missouri Pacific presented the report on Power Trucks and Tractors and said in part:

"We have gotten quite a large number of replies to this questionnaire and I will say that a good part of them do not mean anything. It is rather surprising the number of large roads and roads that are usually considered as progressive roads that do not use this class of equipment at all or only to a limited extent. It is also surprising in some ways the apparent complete lack of any records of this kind of equipment on many of the roads. I think this is partly due to the fact that so much of the equipment is under what you might call scattered jurisdiction. They are apparently not sufficiently interested or perhaps they are interested enough but do not really know how to go about arriving at the cost data, and in many cases they do not seem to think it is necessary."

THE PRESIDENT: "The Chair appreciates the difficulty the Committee had in endeavoring to get facts from the truck and tractor users in regard to this subject from having served on the Committee one time. It seemed then and it does now that it is a question of reluctance on the part of users to giving out information or they do not have any records to show just what their trucks are doing. In many cases the reply is simply that well 'We got them and we use them and we could not do without them. How much cheaper some other method would be we do not know, but we are satisfied. What is the use of keeping records.'

"The subject is open for discussion and I am sure that there are questions that many of you would like to ask."

J. C. MCELREE (M. P.): "In regard to the data on the use of electric trucks for different purposes, I am wondering if the Committee would not get more information if they would endeavor to obtain costs on the per ton basis rather than by the electric process or other processes."

MR. JOHNSON (Central of Georgia): "We have a considerable number of trucks in use on our roads. I try to get the cost on the per ton handled, but that is a proposition that is very hard to do on account of the fleet. If it could be figured in ton miles the same as loads of freight then your cost would be definite, but we are handling from 200 feet to 3,800 feet and it is hard to figure just what a ton of freight would cost to handle on account of the difference in the hauls."

MR. MCELREE: "I was just wondering whether the lift type truck has been used to any extent for the handling of batteries in the yards and battery houses, and if so with what success."

MR. MINICK: "Mr. Chairman, I do not know of any cases where lift trucks have been used for that purpose, but we have in our service a number of electric trucks in which the truck platform has been built high enough so that the battery can be pushed or pulled directly into the car compartment or to the table or bench in the battery house. Several of our yards are equipped with a pretty fair number of trucks for handling batteries in that way."

MR. FARRELLY: "Mr. President, I believe that the proper thing to do is to send questionnaires to the electrical engineer and not send them to the different officials of the road. That would enable the electrical engineer to get the different data and present it in the proper shape. I believe the average electrical engineer is very honest and will give as correct information as possible."

MR. MOORE: "Mr. Chairman, the question of to whom the questionnaire should be sent in this particular case is somewhat of a divided one. I think so far as our general questions are concerned it would be entirely proper and preferable that they go to the electrical heads."

THE PRESIDENT: "Would there be any objection to sending a copy of the questionnaire to the electrical engineer? Many roads ask that questions of that kind come directly to operating officials but they have no objection in most cases to having copies of such requests go to the electrical engineer."

Mr. Andreucetti: "If a railroad is interested enough in a proposition of this kind, and after all we are doing things that are worth something to the railroads or we had better not do them at all, then the proper place for the questionnaire to go is to the head of the operating department, and he in turn will turn it over to the man who is supposed to have the information to send to him. I find that that is generally done where the man has charge and is recognized as having charge. Now, I have followed this truck and tractor proposition for three years and I do not see that we have gotten very much further than we were at the beginning, and we have spent a good deal of time and effort on it. From the lack of enthusiasm and the lack of apparent co-operation from the railroads I am just wondering whether we are not wasting a lot of time. I just bring this matter up for thought and discussion."

Mr. Minick: "Mr. Chairman, there is one item that I think we have overlooked in this matter of questionnaires. I am not speaking of this one in particular, but I am speaking of questionnaires sent out generally. On a great many roads, particularly the larger roads, the matter of answering questionnaires has become extremely burdensome. This is not the only association that sends out questionnaires. There are possibly six or eight associations that send questionnaires to the railroads covering all sorts of subjects. The questionnaire comes to you and you start in a survey and within a week or ten days along comes another one which could have been covered in the original survey had you known it in time."

Mr. Andreucetti: "Mr. Chairman, I am very glad to hear Mr. Minick say what he did. His road has been one of the roads that used to furnish us information consistently and lately has refused. It is largely due to what he has said. We are running into this and it is becoming more apparent and manifesting itself more and more every day that railroads are going absolutely to refuse to answer questionnaires of this association if we continue to send out as many questionnaires as we have in the past year."

The President: "It has been my experience that most of the larger roads compile certain information for their own use. Many committees would be satisfied if they were able to get from those roads such information as they have available. I agree with Mr. Andreucetti that we must be more careful in the future in asking for information."

Mr. Moring: "I would like to ask a question. Is there any one present who knows where they are using gasoline trucks, tractors or shop mules in the car shop or in mills handling lumber? If so, don't you think it is a fire hazard and if you do, why don't you get busy and see if you cannot induce them to put in electric trucks?"

E. Marshall: "The Great Northern Railroad has quite a number of gasoline tractors around lumber yards. I do not know that we have ever had any incipient fires or otherwise. I do not believe that we consider that the gas tractor is any serious menace around a lumber yard."

J. E. Gardner: "On the Burlington we have practically standardized on electric trucks for freight house handling. We are using gas trucks and electric trucks at various shops and storehouses. The gas truck of course is a much cheaper truck. On the other hand, your electric truck does not have such heavy maintenance. Its cost of operation may be higher if you are not equipped with a charging plant. The first electric trucks that were put on the Burlington were put on and our department was told they wanted to charge them that night. Naturally it took a little while to get organized with a charging plant. Since then we have been in on every electric truck installation and have seen that the question of the cost of the charging plant was taken up with the cost of the truck. It is really a part of the original installation.

"I would like to ask how many people are using the ampere hour meter on trucks."

Mr. Marshall: "The ampere-hour meter I consider to be rather essential in the case of trucks that are not in such heavy operation that you have a definite period when the batteries will be run down."

Mr. Diehl (C. & O.): "With reference to the ampere-hour meter on trucks that are run through shop walks, which are badly kept up as for wear, I should think that the ampere-hour meters would not stand up under these conditions."

The President: "I do not think you need to worry about that. If you did have trouble of that kind the meter could be mounted on spring suspension.

"Unfortunately, we will have to close this discussion on electric trucks and tractors. A motion will be in order to accept the report of the committee and to continue the committee."

Mr. Moore: "I make that motion, Mr. Chairman."

Mr. McElree: "I second the motion."

It was carried.

Electric Welding

The report on electric welding was presented by E. Wanamaker of the Rock Island lines who said in part:

"I presume the members gathered here have read this progress report, as it were, on electric welding. I do not think it is necessary to read it now. What time we have allotted I feel could best be utilized in the discussion of the proposed manual. The general manual I feel is a necessity if our Association is to continue to serve the railroads in the future as well as they have in the past.

"Among other responsibilities and one which of course is too great to be included in the general manual is electric welding. The first thing is to aid our people in finding or ascertaining what the possible value of the electric welding process is to them as individual railroads. Second, if it is of value what results can be obtained. I think that was developed very clearly at Atlantic City in the mechanical division of the American Railroad Association last June. When we suggested at our semi-annual meeting that we hoped to develop a manual for electric arc welding the suggestion was received with open arms. It is what they have been wanting. It is what they have been looking for but they did not know where to get it, and frankly there was nobody in our organization who wanted to assume that much responsibility and work that hard in order to get it out. It has been felt that if somebody would pave the way whereby the individual roads could secure the necessary information without undue trouble that there would be greater strides made and the last few years has demonstrated that. This manual we hope to make perpetual if it is duly authorized, covering at least one method of every typical job of welding. If you can find two or three methods that are good, put them all in so that the individual using

the manual can take whichever one appeals to him the most.

"I am now going to shift the responsibility to Mr. Lunn to get an expression from those gathered here as to your recommendations as to whether we should proceed with the manual and if so in what manner."

THE PRESIDENT: "The Committee has earnestly asked that we join it in making the manual a success, and there is no reason why any one should withhold any information that would be of assistance in that direction. I think a motion or a resolution is in order endorsing the plan outlined for preparing the welding manual as covered in the report. Will someone make a motion?"

MR. HAGENSICK: "I so move."

MR. MARSHALL: "I second the motion."

THE PRESIDENT: "You have heard the motion. Are there any remarks?"

MR. SHIRK: "Mr. Chairman, I believe this manual would fill a very long felt want. We are right in the throes now of constructing a manual ourselves. We will stop it just as soon as this Association shows any intention whatever of getting up a standard manual for all of the practices. It is one that we cannot possibly pass by."

THE PRESIDENT: "Are there any further remarks on that question? If not, those in favor of the resolution say Aye, those opposed No. It is carried."

MR. SHIRK: "The welding on the Chicago Great Western Railroad has grown from almost nothing, going back to 1912 when we first started the electric welding. We were then supplanted with gas. Then we passed back on the electric welding. In the past year our electric welding has grown on a railroad of 274 locomotives and 1,400 miles of track from a deposit of 300 pounds of metal a month to almost 6,000 pounds of metal per month. Every day there are new features that no one had ever dreamt of coming up. To illustrate, we have been just recently welding our car roofs. What are we going to do without steel car roofs? We are welding 20 gage metal to 16 and we are welding 20 gage metal to 20 gage. In the car department we have not started to touch the welding possibilities. In the locomotive department we are making a great deal of progress because it was necessary.

"On the Chicago Great Western Railroad we had to adopt a little different program in order to get our welding machines. We could not pay for them. We could not go to the management and tell them here is what we could do if we had electric welding machines. We finally came to the conclusion that we would try it out a little different way and so we asked an electrical man to go to our management and tell them they could make a saving through electric welding and tell them the method by which they could do it. The general manager said, 'Well, I will listen to it.' The welding machine manufacturer said, 'We will supply you with welding machines and you pay for them out of the savings you make and you say what the savings are.' The general manager said, 'Well, I have never heard of such a hair brain arrangement as that but I will try it.'

"Therefore, a system was inaugurated and when we want welding machines we just say how many machines we want and they are paid for out of the savings. We put the savings at one hundred per cent. Twenty-five per cent of the savings is deducted for the cost of the installation of the machine. Of the seventy-five per cent of the savings ten per cent goes to the manufacturer for supervision, sixty-five per cent towards the payment of the machine. In that way the manufacturer has a way of selling machines and giving service. It is perfectly practicable. It has worked out in our case and it will work out in every one's case where they are interested, whether or not they are large buyers or small buyers. We found that our cost of gas welding was from $2.75 to $3.15 per pound of metal deposited and on electric welding from thirty-two cents to sixty-five cents per pound of metal deposited. Our payment on these machines is running from $3,000 to $4,000 a month. Now that is $36,000 to $48,000 yearly and only counting a third of it."

The report was accepted and committee continued.

Electric Storekeeping

The report on Electric Storekeeping was presented by E. Wray of Purchases & Stores.

MR. MOORE: "One of the difficulties of having a fully trained electrician in charge of the electrical stock seems to be that store rooms do not pay as much as the electrician would get if he were working at his trade."

MR. ANDREUCETTI: "The ideal proposition, I believe, is to have an electrical man as an electrical storekeeper in charge of all electrical materials under the general storekeeper. He would have charge of electrical engineering material, signal material, telegraph material which is more or less electrical. He should have a fair knowledge of the requirements of those different departments. If he is a good electrical man or even a good signal man he is a very apt pupil to get familiar with and educated in the other branches of electrical materials in a short time. We have such a man and the system I just mentioned is in use on the North Western Railroad. I think it is highly desirable, while it may not always be possible, to have such men."

MR. GALLAGHER: "Mr. President, I would like to ask on roads that do not have a special man like they do on the Chicago North Western, does the electrical engineer or his assistant take occasion to visit the storekeepers to see that they do have the proper amount of material to protect themselves in case of emergency?"

THE PRESIDENT: "Is that practice quite general, do you think?"

P. J. CALAHAN (B. & M.): "That practice is followed out on the Boston & Maine road on all electrical matters."

B. C. EVANS: (E. P. & S.): "That is also true on the El Paso and Southwestern."

D. J. CARTWRIGHT (Lehigh Valley): "I am very glad to state that same practice is carried out on the Lehigh Valley."

MR. MINICK: "Mr. Chairman, there is one phase of this question of storekeeping which I think the Committee could very well give some thought to and that is the utilization of the stores department as a means of ascertaining what you actually have in your service and from that effecting standardizations.

"I had occasion here a couple days ago to make a survey at Altoona in the four shops of the motors used. I found that we have roughly 2,600 motors. We have of the 26 makes of motors, 43 types and 190 some sizes. Now nobody realized that condition. That condition, like Topsy, just grew."

A motion was carried to accept the report and continue the committee.

THURSDAY SESSION

Safe Installation and Maintenance of Electrical Equipment

The report of the committee on Safe Installation and Maintenance of Electrical Equipment was presented by R. F. Miller of the Chespeake & Ohio Ry. The discussion was opened by Mr. Marshall who said:

"In the Committee meeting Monday afternoon I was very much struck with the fact that almost every one in the room had had experience with the danger of low voltage circuits to human life. I would like to ask if any of you have ever considered the practice of using low voltage, such as thirty-two volts for extension lamp service. We on the Great Northern have done that. In every roundhouse that is lighted with alternating current we have a special 32 volt transformer which serves the purpose of giving you low voltage which is not dangerous and insulating the extension cord and the extension lamps from any accidental contacts that might occur to your main lighting system."

Mr. Shirk: "In a direct current shop we were against the same proposition—220 volt direct current circuits. We tried the proposition of setting up a train lighting generator and it did not work out very well. We set it up without any regulators whatever and we experienced so much trouble with that lamp dimming and jumping up we had to discontinue it."

The President: "You have figured the cost of making the 32 volt installation as being not so high as to prohibit it in most cases, have you?"

Mr. Marshall: "In our roundhouses we install one transformer of about 500 watts capacity in each section of five or six pits. We had to design transformers and wind up the coils. They cost about $11.00 a piece. The wiring is very simple. I presume that a section of the roundhouse can be wired up for this kind of service for from $200 or $300 a section, which is not at all excessive."

Mr. Moring: "I would like to ask the members present how many of you know that you have an additional ground wire connected to all of your portable equipment?"

Mr. Keesley: "We have been making the practice of getting receptacles that carry an extra wire. We use a four wire conductor. Our receptacles and portable tools are all equipped with ground."

C. R. Sugg (A. C. L.): "In my section of the country we run through six or seven states and I do not know of a single instance where we have any legal requirements with reference to it. We all go by the National Electric Code and there is no absolute requirement. Since we started on this Committee report, however, everything that has gone onto our road, new work especially, carries the same receptacle that was just referred to."

Mr. Moore: "All protecting devices involve the matter of safety both of the apparatus and life, and as the fuse is one of the most susceptible protective devices of improper handling I would recommend to the manufacturers that they attempt to develop a relatively small circuit breaker which will do the business of the present small sized fuses. There are at present in Europe small breakers which are not much if any larger than our standard push button switches running up to 10 or 15 amperes."

The President: "Mr. Moore, were they slow acting circuit breakers?"

Mr. Moore: "They are both instantaneous breakers. There is a field there for development if the manufacturers will just go to it. It seems to me that the fuse is one of the most readily doctored pieces of apparatus that I know of."

Mr. Andreucetti: "Have you ever found circuit breaker tied?"

Mr. Moore: "That is the reason I mentioned that they should be inclosed and trip free from the handle."

Mr. Shirk: "Mr. Chairman, paragraph 6, installation, it is recommended that all high voltage wiring (601-5000) shall be in lead covered or armored cable run in conduits where used for interior work. I would like to get the expression from the various members on that. Our experience with lead covered cable has been disastrous. In nearly all the places in which we operate where there is an inspection bureau we are doing away with lead covered cables entirely. I would like to know what the opinion of the various numbers is."

Mr. Andreucetti: "Mr. Shirk, lead covered wire underground circuits is mandatory in a lot of cities."

Mr. Shirk: "I know it is."

Mr. Andreucetti: "In Chicago it would not be left to you to decide whether or not you would use it. I agree with you that we have had more or less trouble with underground lead covered wire, but in places of this kind we have got to put it in."

Mr. Shirk: "With approved installation you can put in rubber covered wires underground in conduits."

Mr. Andreucetti: "What is approved installation?"

Mr. Shirk: "High grade 30 per cent Para."

Mr. Andreucetti: "We are not permitted to do it."

Mr. Moore: "We have not used any lead for a long time, and most of the lead we did buy went bad and the ordinary insulation went bad with it. We got rid of it and put in what we consider is the highest grade insulation and had practically no trouble."

T. F. Foltz (Wash. Term.): "We have had considerable trouble with lead covered underground cable due to electrolysis. In the past ten years we have taken out quite a few miles of lead covered cable and substituted high grade rubber and have had no trouble since."

Mr. Moring: "Getting back to the portable equipment again, I would just like to ask a question. In how many different railroad shops is it customary to make a periodic inspection of all your portable and your hand tools to ascertain if it is necessary to make any repairs."

Mr. Andreucetti: "Mr. Chairman, I think therein lies 80 to 90 per cent of the trouble. That is not done, and the circuit breaker and other apparatus is not a cure for a condition of that kind. I think what Mr. Moring has said, if it were followed out, would answer our purpose today."

Mr. Bebout, Jr. (C. & O.): "Mr. Chairman, we make inspection of all portable drills and such tools twice a week and find that method very satisfactory."

Mr. Sugg: "I have been trying to break my men in to do that, but it is the hardest job I ever had in my life to make them do it."

Mr. Foltz: "Is it proper to make a recommendation or an amendment now?"

The President: "Yes."

Mr. Foltz: "I take exception to the sixth paragraph

under installation where it says it is recommended that all high voltage wiring shall be in lead covered cable. I move it to be stricken out."

MR. SHIRK: "I second the motion."

The motion was not carried.

Illumination

The report on Illumination was presented by Mr. Billau, the chairman of the committee, who said in part:

"Since presenting the report it has been brought to my attention that the demand for the 15 watt, 32 volt lamp in the G-18½ bulb is still so large that there will be use for it for some time to come with the result it was thought desirable, at least for the coming year, to include that lamp in Table 3 of recommended sizes of lamps.

"In preparing the first part of this work this year one of the things we wanted to obtain was the suggestions from the members as to what would be desirable in the scope of a work of this character. The committee was confronted with the fact that the greatest difficulty was going to be to boil it down as to what would really cover the meat of the subject without getting into something that would be too voluminous. So far the committee has confined its activities solely to the question of presenting its illumination problems and with such engineering data as to aid in their solution with the view of leaving to the individual engineer the question of selection of makes and types of units to obtain the desired results, the question of wiring practices, and so forth.

"I would like to say there is one typographical error here that ought to be corrected. On the table at the bottom of page 313 under the heading marked recommended intensities you will find the values beginning showing .4 to 8. There is a decimal point that does not belong there for the last three figures in that column. It should be 4, 6 and 7 instead of the decimal point in each of those figures."

THE PRESIDENT: "It is evident from codes adopted in the various states that facts regarding the desirability of having well lighted buildings have been well circulated and as a result the legislative action is and will be such as will insure many changes for the better in old plants and better initial conditions in new. It would seem on the showing made on one railroad the flood lighting industry ought to thrive. A fifteen and one-half per cent increase on the current handled with a 21 per cent decrease in average cost of damage to cars handled at night and the elimination of personal injury caused by insufficient light should be enough to establish a sentiment in their favor."

MR. MOORE: "Mr. President, I think the Committee on Illumination is to be very greatly complimented on the work they have done so far. There are some things in the committee's report that I would like to comment on and one of them is the flood lighting proposition. If flood lighting is to be used it seems to me it should be placed along the sides of the yard with the lamps directly diagonally across the yard, and, of course, at considerable heights."

THE PRESIDENT: "Now you have all read the reports, I assume, and a resolution endorsing the work done on the manual and plans for carrying it on to its completion will be in order."

Motion was carried to complete manual.

MR. MOORE: "Under the subject of glare, section 112 in the proposed manual, the flood lighting proposition is one that comes up and it is one of the reasons that I rather object to that system except in very special cases. In connection with the selection of equipment I think it would be well to include something with reference to it in the committee's manual."

MR. BEBOUT: "I would like to call your attention to page 332 lighting systems shown in Figs. 12 and 13. All of our engine houses built since 1916 have that system of lighting, but the first one was 12 feet, as shown in the drawing in Fig. 13. We found that that was too low and we have raised them about 18 inches, making them 13 feet 6 inches. Otherwise, a man will be using portable lights on top of the larger engines. In this system of lighting installed since 1916 I do not know of a dollar being spent in maintenance, but with the old system overhead in conduit we had to replace it about every two years."

MR. KAHLER (O. S. L.): "We have two systems of outside lighting. One is flood lighting and the other is using 1,500 candle power units. I don't think that there is any comparison between the two. The 1,500 candle power lighting on account of its more even distribution and lack of glare is far superior to the flood lighting.

"In regard to the office lighting I have found that we can get a lot of support by getting your medical department interested. In one office in particular there were fourteen clerks and twelve of them were continuously going to the doctor for eye strain. Six months after we got through, there were only three out of those twelve continuing to go to see the doctor."

MR. MCGARY (N. Y. C.): "We have been asking for the P. S-18 lamp for use in our cars. Our cars are all equipped for use of the 18 sized lamp. We took it up with the A. R. A. Convention at Atlantic City and also this association, and I feel that it should be included in the list of standards, as at present we are penalized in buying that lamp. Our officials feel that the improved appearance of our cars justify our stand on insisting on that lamp. I think it should be included."

MR. BILLAU (B. & O.): "If my understanding in the matter is correct, the P. S.-18 bulb is not a standard bulb with the manufacturers. To introduce a new sized bulb into the lamp field is going in exactly the opposite direction from the whole trend of activities to reduce the number of types. If the lamp possesses merit and it has a sufficient demand in the railroad field, obviously it could be adopted, but in doing it we want to eliminate what is now being used in the 25-watt size."

MR. GANZERT (R. I.): "As a matter of information I would like to know if anybody has noticed the difference in the light of the PS.-16 without the center anchor of the filaments. On the Rock Island we find that the lamp without the anchor adds about 25 per cent to the cost. The filament seems to sag and break off at the end."

MR. CARTWRIGHT: "We had a little experience with the anchor lamp and the non-anchor lamp in those sizes and we have particularly recommended to the purchasing agent to insist on having an anchored filament."

MR. GANZERT: "The PS-16 lamp as turned out today, I understand the center anchor has been eliminated entirely on all classes of lamps. We get a 32-volt lamp without the anchor and they last about 75 per cent as long as the original lamp."

A. L. BROE (Edison Lamp Works): "There is just one thing that I would like to make sure of in this point about the anchored filament. We have had several different

constructions there in the course of the last few years. Originally we made that lamp with a certain type of filament and then from that we went to a V-shape filament and the present construction is a filament which is almost a straight horizontal filament with a very slight sag in it. Now I would like to know if the gentlemen who have found the unsatisfactory results are referring to the present construction which is almost a straight filament or whether they are referring to the V-shape filament. We do not believe that the anchor is necessary in the present construction of the lamp."

MR. GANZERT: "This was within the last two weeks. They are a straight filament lamp."

MR. ANDREUCETTI: "Mr. Chairman, Mr. McGary has this PS-18 lamp and has used it consistently now for several years. Let us dispose of this question one way or the other, before we go on with any other point."

MR. MORING: "It seems to me it is narrowed down to just one or two things, continue on the recommendation of the committee and use our lamp as recommended or change the shade so that we will be able to use that lamp instead of using the 18."

MR. MCGARY: "I would say that the New York Central Lines have upwards of 3,000 coaches fitted with these shades and lamps and the change is a big expense. We adopted the 18½ size years ago, after a great deal of study and we do not feel we ought to have a lamp in there out of proportion to our shade to meet the standards and we do not want to go to the expense of changing our shades. I do not feel it is a new lamp. We formerly used the 18½ size and there is only a half size difference."

MR. MINICK: "There is this to be said about the recommendation of the Committee of the P. S.-18 bulb or any other more or less special bulb lamp as a standard. If, as Mr. Billau said just a minute ago, the railroads want to use PS-18 bulbs, we would be very glad to do it provided we make space for it by dropping out something else. The Pennsylvania is using in car lighting service three or four odd sizes and shapes in lamps and we have no thought whatever of asking this association to make them standard or ordered to save a few cents on the purchase of those lamps."

A vote of thanks was then entered to the committee for its very able report.

Self-Propelled Cars

The next report was that of the committee on Self-Propelled Cars. In introducing this subject the president spoke as follows:

"Any one interested in this particular subject can very profitably study the committee's report. The railroads appear to have a problem that they do not exactly know what to do with. The committee has made a frank and clear statement of the conditions as they now exist and the groundwork has been prepared for future investigation and recommendation. The subject is now open for discussion."

MR. ZIMKOWSKI: (New Haven): "Mr. Chairman, I would like to ask if there will be any objection to using the self-propelled cars in mail service."

MR. WANAMAKER: "I had a little experience recently with the R. P. O. compartment in motorized equipment where the motor car equipment, the body, is narrow, and the standard equipment can be installed."

MR. CALAHAN: "I would like to ask if the changing price of fuel oil will have a material bearing on the development of the self-propelled car industry."

MR. GAGE (Can. Pac.): "Mr. Chairman, your committee feels that the fuel supply of the future is well guaranteed. Naturally the petroleum oils, the oil shales and the regular gravity oils will be available for years. We do not need to worry yet about that."

MR. MILLER (C. & O.): "Mr. Chairman, would it be the general opinion that as the automotive equipment is developed on the railroads we can take our present forces and train them to maintain it, or would it be better to bring mechanics from the various automotive concerns and let these men handle that end of it?"

MR. GAGE: "It has been our experience, Mr. Chairman, that it is very desirable to get fully competent men in this kind of work rather than to try to use the men experienced in locomotive maintenance."

MR. SHIRK: "We have on the Chicago Great Western the greatest collection of motor cars, all types, sizes, shapes and forms with the exception of the storage battery car. On the maintenance, I say make your own men, build them right into it. Take your mechanics from your shop. It is not necessarily so that because a man is a locomotive mechanic that he is not a mechanic for anything else."

MR. MCPHERSON: "In reference to going outside for men for the maintenance of this equipment, from an experience in about eighty-five installations we are inclined to believe you will be better off training your own men and not go outside for so-called experts."

MR. MINICK: "I would like to ask the manufacturers if they won't stick closely to the types of lamps used in automobile service. We bought two or three cars lately and we find almost anything in there but a standard lamp."

MR. SHIRK: "The Chicago Great Western specifications call for standard train lighting lamps and we use them."

MR. CARTWRIGHT: "I think you find the standard train lighting specification lamps are going to get you into trouble. On a small rail car it is much better for you to go to the 15-watt lamp and use the automobile type of lamp. If you go to the larger size, 30-volt lamp, you have got to increase your storage battery, the size of your storage battery, and you will be called upon from time to time to recharge your batteries, whereas with the small 15-watt lamp the engine on the car itself is always sufficient to keep the battery up to the full state of charge."

MR. MINICK: "Mr. Chairman, my request was for the automobile lamp."

MR. SHIRK: "Our experience with the automobile type of lamp was that at the end of each run we had to buy a new set of lamps. You will only run your car three trips until you will put your lamps on the Edison screw base."

MR. NEWBOLD: "I think this is a train lighting proposition and we ought to start in with a 32-volt standard lamp. It falls right in this organization and we ought to set a new standard right away because it is coming. It is bound to come."

MR. BEBOUT: "It is my opinion that the converted bus should be kept off the railroad. If we are going to use the bus, use it on the highways as a feeder. Get your cars as near railroad standards as you can and insofar as the maintenance is concerned I do not see that there is anything about the standard type of cars that our shopmen

couldn't handle. Every railroad has used gasoline motor cars and gas oil engine equipment for years, and our shopmen can take care of those cars as easily as an outside automotive man."

The report was adopted and the committee continued.

Starters and Controllers

The report of the Committee on Starters and Controllers was presented by J. E. Gardner. The discussion was opened by Mr. Bebout as follows:

"As outlined in the beginning paragraphs of this report we did not attempt to make any specifications for the manufacturer of controls. What we desired to do was to get up a recommendation for controls that should be used on the railroad."

MR. SHIRK: "I would like to ask the engineers here if any of them have an automatic starter in use with a synchronous motor on an air compressor 50 horse-power size, approximately 300 cubic feet capacity where the air compressor starts and stops 15 to 20 times per hour, the compressor located in an isolated location, electrical inspections covering say from 30 to 90 days. I would like to get in touch with whoever has such an equipment. I am very anxious to find somebody who has such an installation."

MR. BEBOUT: "Mr. President, I would like to say in reply to one of the questions that we about eight or ten years ago bought two compressors identically alike in every respect except controls and wanted to try out to see which was the best in service, the automatic starting and stopping. We found the automatic starter so unsatisfactory in cost of operation that we took it out and put a manual starter on and ran it with an unloader rather than to start it and stop it."

MR. SHIRK: "I might say in this connection that we have eight compressors at other points on our railroad for charging and testing air on freight trains and it is not a new thing. The operation of the compressor is absolutely satisfactory. The point is the starting and stopping of a synchronous motor in the same service."

MR. WINSLOW (Mich. Cen.): "I saw the other day in the plant of Dodge Brothers Automobile Company in Detroit a 200 horse-power synchronous motor started automatically, and it was very successful. Now that did not have the control features of the cooling water nor unloading, but there would be no reason why they could not be added, and I think this equipment would answer the purpose. I would like to say this, in the first place, that a motor driven air compressor which starts more than ten times an hour is uneconomical, and a mechanical unloader should in preference be used and will use less power."

MR. SHIRK: "Mr. Chairman, I wish to state for the gentleman's information on the air compressor in starting and stopping ten to twenty times per hour it at no time exceeds the full running load for starting. Therefore, there is no inherent waste."

The report was accepted and the committee continued.

THE PRESIDENT: "We are all much interested in the question of heavy electric traction and although there will be no committee report, we are to be favored with a paper by a man well qualified to present the subject and who will discuss some of the important aspects of this larger question. The paper is prepared by R. E. Wade, but I understand that C. C. Bailey of the railway department of the General Electric Company will present the paper."

Mr. Bailey presented the paper.

THE PRESIDENT: "It is a question that we as electrical engineers should give considerable thought to, and this paper I believe will be in the proceedings and very likely will serve to awaken us to some possibilities that we have not thought of before. If there is nothing further to be said in regard to any of the subjects presented this morning at this time, the meeting will stand adjourned until tomorrow morning at 9 o'clock sharp."

The meeting then adjourned.

FRIDAY SESSION

Automatic Train Control

The final session of the convention opened with the report of the committee on Automatic Train Control which was presented by J. P. Nelson of the C. & O.

THE PRESIDENT: "This subject appears to be one of expediency to a considerable degree. The public's demand for maximum safety in transportation has inspired the hope that some miraculous solution will be found for the many questions involved. It becomes evident, however, as time passes that there are difficulties to be overcome which will tax the ingenuity of many experts, including the electrical engineer. The subject is now open for discussion."

MR. MARSHALL: "I would like to ask if it has been found in the operation of this automatic train control that the wiring or any of the electrical connections had to have a different design due to the characteristics of the service, that is, due to vibration or any other condition than ordinary electrical design of other apparatus."

MR. NELSON: "In one sense I would say it does. We use what we call a No. 18 switchboard cable vulcanite, 19 strands, extra flexible. We are particular in making eyes and soldering them and always using double nuts and screwing them up to a terminal. It has been remarkable the trouble that has been caused from just some little loosening and we had to overcome that in various ways."

MR. MILLER: "I would imagine then that we should work up some special design which will take care of that particular condition. If loose connections which in ordinary operation would not necessarily cause failure, is almost sure to cause failure, then we ought to have some special design to take care of that."

MR. NELSON: "It is very noticeable where you take headlight men and put them on that work. They do not seem to realize the great importance of having clean connections and being cautious in tightening them up and putting double nuts on them. We have almost gotten away from broken wires with the exception of three cases last month and that was due more to carelessness than anything else. A man used a piece of stiff wire where he should not, and in putting a jumper on the battery lead was not soldered properly. There is always a slack on our wire when it comes out of the conduit onto the terminal; in fact, if our eye gets bad we always have room to skin it back and make another eye."

MR. MORING: "How frequently is it necessary to inspect this equipment?"

MR. NELSON: "We make an inspection every time we come to a terminal."

MR. MINICK: "It is a pretty well-known fact if terminals are soldered on a wire there is some crystallization of the conductor. I have been wondering whether anybody has developed a solderless terminal that can be applied to stranded wire."

MR. BYRNE: "The biggest problem in this train control, as I see it, is to keep the grounds off. There is a problem that a fellow is up against. With train control in fast service you will have all kinds of difficulties, not only the water getting in the wiring, but also oil in the conduit and the wire chafing in the conduit."

MR. NELSON: "In answer to that we have had some trouble in using flexible conduit. We have gotten away from it entirely and use the rigid conduit, and so far as getting oil, water and so forth, in the conduit, we are not experiencing that any more."

MR. KENEDY (Pyle Nat. Co.): "Mr. Chairman, at the present time we are in the process of redesigning both the K-2 and the E-2 types of headlight equipment for special adaptation to train control. We are incorporating in that what we believe are all of the requirements of the machine which will eliminate ground, and at the same time paying special attention to voltage pulsations or alternations in the direct current wave, particularly for use with continuous induction systems of train control. The members here who have the continuous induction control know that any pulsation in the direct current wave will result in the loading up of the vacuum tubes and the train control companies aim to work the vacuum tubes at a very low rating. We have also incorporated a more effective oil seal so that you are not going to be subjected to the troubles of oil and dirt getting on the insulation."

MR. WANAMAKER: "I think we were the first railroad to equip an operating division completely with train control and I found that train control designers as a whole apparently but little understood the braking of trains. It seems that the major efforts of the train control designer had been directed to perfecting a method for transferring a signal indication in some form of impulse to the locomotive, but unfortunately after they got it to the locomotive they laid down on the job. The big job after all is to brake the train. I believe that those who have actually, carefully investigated train control and will give us an honest opinion will agree with me that the big end of train control is the locomotive devices. Without the locomotive people, mechanical as well as electrical, and especially the air brake people, I do not see how you are going to have much success.

"The signal engineers, insofar as the transmission of the indication is concerned, have largely worked that out, but we have not completed the other part of the program. I want to say something else about the transportation part. I might say that when we started to operate our train control we immediately bumped into the lifelong, insofar as signals are concerned, rule of the railroads that no train must proceed beyond a stop and proceed signal when set at danger under any consideration until first coming to a full stop. The argument waxed hot, fast and furious for two or three months. I do not think we have ever had any trouble due to changing that operating rule. We have eliminated a lot of unnecessary stops with that form of train control. If you do not take advantage of the opportunity that is offered to permit the train to proceed the chances are that you will greatly hinder your train operation, in other words, will reduce your track capacity. Sometime ago I figured $1.92 for stopping the average train on a passing track with remote control switches, and the chances are it will run possibly $2.00 where you do not have remote control switches.

"I would like to see the electrical engineers get ahead, and I believe that automatic train control is offering a very satisfactory extension to the field of operations for the electrical engineer, probably the best field that he has had because it will put him directly in touch with train operation."

The report was received and the committee continued.

Locomotive Lighting

The report on Locomotive Lighting was presented by L. C. Muelheim of the Baltimore & Ohio, and the discussion was opened by Mr. Marshall, who said:

"I have already taken up with the committee the point in connection with the S-14 lamp for cab lighting. The S-14 lamp has been tried out on the Great Northern Road and we find it satisfactory, but the Purchasing Agent has found that he has to pay more money for it. Consequently he wants my approval for changing back to the S-17. Now, I do not like to do that if it is found that the S-14 will ultimately become a standard."

MR. MINICK: "The development of the S-14 bulb lamp was brought about primarily by objections or criticisms on the part of railroad representatives to the size of the S-17 lamp. As time went on the lamp was developed and we are now in the position of trying it out and proving its worth before recommending to the association that it be adopted as a standard."

MR. MORING: "Mr. Chairman, I would like to ask how many railroad representatives here are using at present the S-14 lamp."

THE PRESIDENT: "All those who are please stand."

(Three stood up.)

MR. SUGG: "On page 336 I note that it is strongly recommended that 32 and 33 volt lamps be used. What is the reason for using two voltages?"

MR. MUELHEIM: "The 32 volt rating was the original rating of the headlight lamp and it appears that it was advisable at one time to give a cab lamp a little different rating on account of the variations in the turbo-generator and permitting a little rise in the voltage that would not affect the cab lamp as greatly as it would the headlight lamp. The cab lamp always did seem a little more delicate than the headlight lamp and the little rise in voltage seemed to affect it more generally."

MR. BROE: "I am rather hazy in my recollection of the reason for that. The cab light is sometimes used when the headlight is off, and under those conditions you are likely to have a higher voltage which would strain the cab light."

THE PRESIDENT: "It is not desirable, of course, to have lamps of two voltages if it can be avoided."

MR. MINICK: "The headlight should work at its highest efficiency. With the average type of headlight equipment regulated to 32 volts we can get very close to 32 volts in the headlight. In the case of the cab lamp and other lights used on the locomotive we want not only a reasonable efficiency, but we want long life. A difference of about five per cent in the voltage of the lamp will make a difference of probably forty or fifty per cent in the life of the lamp and that, combined with the fact that

when the headlight itself is not operating, gives us a condition of having a little higher voltage on the circuit, and has led to the selection of a little higher voltage for the auxiliary lamps."

F. J. Hill (M. C.): "Mr. Chairman, in regard to the G-25 lamp, it is not clearly understood just why that lamp was recommended by the A. R. A. In the early days of the headlight lamp we had a great deal of trouble with the bases loosening up. Since the lamp manufacturers have gone to bakelite that trouble has disappeared. It does not seem now it is necessary to go any further with the development of the G-25 lamp. We sometimes overlook what brings these things about and at the time, say six or seven years ago, a good many railroads did have trouble with the bases."

Mr. Hagensick: "To get a line on this I believe it would be a fair question to ask how many roads have tried the G-25 and have not adopted it."

The President: "Will those stand, please?"

(Eleven stood up.)

Mr. Bebout, Jr.: "I would like to ask if any roads have found in this new development of the double filament headlight lamp that the 50 watt filament has been broken and the 250 watt filament has burned out?"

Mr. Hill: "We have carried on some tests along that line and we found in some cases the major filament would break and in other cases the supplementary filament would break. Our instructions were in case of the failure of a filament the engineer will proceed to the next regular stop and then change the lamp, and we have found to our surprise he prefers to finish his run."

Mr. Gardner: "About this G-25 headlight lamp the trend of the lamp manufacturer in the last number of years has been towards the smaller lamp bulbs throughout, not only train lighting lamps, but the lamps in general use. Not very many years ago we had a 60 watt lamp with a skirted base that was bigger than the present 100."

Mr. Stover (Nat. Elec. Lamp Assn.): "The trend of the lamp business, as Mr. Gardner stated very clearly, has been downward. There is no question but what it is cheaper to make the smaller sized lamp assuming an equal demand in general and the fact that gas filled lamps operate better as the bulb size goes down within certain limits, has been another reason why the manufacturer has been continually going down in bulb size."

The report was accepted and the committee continued.

Train Lighting Equipment and Practice

The report on train lighting equipment and practice was presented by Mr. Lunn, Mr. Hill acting as chairman, while Mr. Lunn presented the report. Mr. Minick opened the discussion, saying:

"Before we get into the discussion of this paper, I would like to call attention to the last part of the report with relation to the withholding of the approval of standard practice of the 25-watt lamp in the G-16 bulb and 100-watt lamp. I would like, if it meets with the approval of the committee and the association, to change that and recommend their adoption at the present time as standard practice.

"I want to make another recommendation. We run into more or less trouble in the standardization of lamps out in railroad service by reason of the fact that the Headlight Committee is handling the lamps used in locomotive service, the Car Lighting Committee is handling the lamps used in train lighting service and the Committee on Illumination is handling the lamps used in shop service. I should like to recommend to this association the advisability of turning the entire lamp problem as a product turned out by the manufacturers of lamps over to the attention of the Committee on Illumination, which probably handles at the present time ninety-five per cent of the whole lamp problem. It will tend to reduce confusion, I think.

"I make a motion to the effect that recommendations to the association for the adoption of standards relating to incandescent lamps regardless of their service be handled by the Committee on Illumination hereafter."

The motion was carried.

Mr. Voigt: "Mr. Chairman, in regard to the statement with reference to high priced rubber jars, I believe in using a good grade of rubber, sufficiently good at least to meet the service of the railroads. Of course, I realize that the Pullman Company have a different condition than some of the railroads who are maintaining battery equipment. I want to state that we have been using hard rubber jars since the year 1902 and our present jars since 1907, and have about fourteen hundred sets of batteries in hard rubber jars; in fact, we have no lead lined tanks. Our cost of breakage per car per month on a chair car coach is nineteen cents, on a Pullman car twenty-four cents per car per month. We are not using a high priced jar."

Mr. Lunn: "I would like to move the approval of the recommendation given on page 349 in regard to the changes in dimension of the battery boxes and other matters referred to."

Motion carried.

Mr. Ganzert: "Mr. Chairman, in the second paragraph on page 349 we followed this practice for some time, and we found that leaving the tray in the second paraffin bath for about fifteen or twenty minutes, put in considerably more paraffin. Now we follow the practice of leaving the trays in the tank until they sink to the bottom and we find about thirteen pounds of paraffin in each tray."

Mr. Farrelly: "I would like some information on coach lighting on suburban trains from the locomotive headlight generator. We have on the North Western one train that has been running seven or eight years. The cars have been lighted from the headlight generator and we are not experiencing any trouble whasoever.'"

Mr. Bebout: "With the coaches lighted from the headlight, what is your lighting load?"

Mr. Farrelly: "650 watts."

Mr. Bebout: "What sized generator?"

Mr. Farrelly: "3 kw."

Mr. Dimond (Soo Line): "I should like to ask if there are any batteries used with that turbo-generator?"

Mr. Farrelly: "No, sir."

Mr. Calahan (B. & M.): "On the Boston & Maine we are equipping two trains with this head and lighting system. The cars are 58 feet long. We are installing six 50 watt type C 64 volt lamps. The end lamps are located about six feet four inches from the end of the car. The remaining four are equally distributed between the two end lights, and recent tests which have been made showed foot candle power readings on the average of 2.2 at the window seat and 3.2 at the aisle seat. These cars have not gone into service yet. We expect to put them in within a couple weeks."

MR. ANDREUCETTI: "The situation, as I see it, is largely individual with the railroad. If a railroad company, for instance, as we have found it up to the present time in suburban lighting on the North Western, can be taken care of without an auxiliary battery due to ideal operating conditions with the locomotives on the car, that is, of course, the most economical and gets away from the battery maintenance cost. On the other hand, another road may have another physical condition where the locomotives are detached and the train has to stand for the loading and unloading of pasengers without the locomotive. There you would want an auxiliary battery service of some kind."

The report was accepted and the committee continued.

Radio Application to Moving Trains

S. D. Dimond presented the report on radio and the president touched upon some of the outstanding factors as follows:

"The interest of the radio and the demand for better results have stimulated great activity in all directions in this particular field. It is now next to impossible to locate the receiving instruments so that they will not occupy space that should be reserved for other purposes. Perhaps a shallow, vertical case would answer the purpose. There does not appear to be any antenna difficulties, but satisfactory interior arrangements have not so far been made. I would like to call on Mr. Westcott, who last year was the chairman of the committee that reported on the radio and who has made a very extensive investigation of radio."

MR. WESTCOTT: "One of the biggest questions that has come up ever since the radio application to trains has come about and which comes to me off and on continually is: Is it a success as far as the passengers are concerned? Is it worth while? I cite as an example that installation that was made about two years ago on the Chicago, Milwaukee & St. Paul.

"Briefly, it was decidedly a success. Some people rode that train when there was not a sound out of it. Some people rode that train when there were unworthy sounds. Some people rode it when it was excellent. I might say that at the time there were between 400 and 500 stations all of the same wavelength and their power was not what it is today. We had interference problems which have now been worked out. We had sets that we now would be unable to get on the market. Today everything is changed. We took the loud speakers off and put individual phones throughout the car. The maximum in use at any time that we had was about 28 pairs. That was more popular because you did not have to listen if you did not want to and you satisfied the grouch. On the other hand, I have seen that car so crowded that it was almost impossible for the conductor to collect his tickets. I have seen everyone of those pairs of phones split so that two people would each use an earpiece and crowded throughout the car with hardly a soul in the rest of the train. I have had as many as twenty men come up and inquire about it, and if that is not interest I do not know what is.

"As to the dispatching, Mr. Dimond spoke of that cab to caboose outfit. While it was very crude yet it is a step in the right direction. It needs co-operation from the manufacturer. It provided for a 50 watt double transmitter and loud speaker and receptacle, so much so that they claimed it would call an engine man down working around the drivers into his cab with a signal from the caboose. That is the extreme in expense, power supply, weight, bulkiness and all the rest, that seems a little bit unnecessary. I think we should tend to something simpler and then the average maintainer can handle it. It ought to be simple and light in weight.

"In the dispatching line, one thing has been brought up and that is communication from a signal tower to an approaching train. Wires will go down, tracks will go out and bridges will get into trouble and the radio spans it all. After all your signal connections, your wires to the semaphore, your electric service, all of that goes out and yet your radio impulse can go out of that tower before the crossover is reached. It seems as if the committee's work really trends into something more useful along that line."

THE PRESIDENT: "You have probably just as many people who like the radio on the train as those who do not, as you do here in this hotel, but in your opinion it would be a business getter on any train, especially a transcontinental train?"

MR. WESTCOTT: "Yes, sir."

THE PRESIDENT: "If the demand ever comes, no doubt people who travel extensively will wish to carry their outfits with them, in which case it will be necessary for the railroads, including the Pullman Company, to provide antenna connections, and I may say that is not a difficult thing to do."

MR. WESTCOTT: "I might add one more thing. A little over a year ago one of the officials in going on a pleasure trip through the country which included New Orleans, Los Angeles, Seattle and home again, had a set. Nobody in that car had ever seen a radio before, but one of the party had had a lesson the day before and with a little help from a radio operator on one of the outbound trains for a few minutes, they sat and listened to stations, from five to twenty-five each night, at high speed, from South Dakota to the Hawaiian Islands."

The report was accepted and the committee continued.

Power Plants

The report of the committee on power plants was presented by C. G. Winslow of the Michigan Central, and the discussion was opened by Mr. Foltz, who said:

"I think it might be well to add a little more on the matter of water regulators. The question is whether we want to keep a constant level. I think it has been generally conceded that that is not what is desirable. In other words, there are regulators on the market now which will feed the water in a way that it will lag behind the level. If there is a heavy demand for steam instead of the regular feeding in immediately to keep the level constant it will permit the level to drop and thus the furnace which is overtaxed at that time to supply the heavy demand has a chance to adjust itself to the new conditions of the heavier load and by the time the water comes up to that level there will be a greater supply of steam. On the other hand, if there is a sudden drop in the load and if the feed water regulator immediately starts in order to maintain the water level, the safety valve will pop off and you lose power. In that case the level is usually permitted to rise. The comparatively cold water coming in there absorbs the excess energy which is given off by the furnace

and is not used for the the generation of steam until the furnace has a chance to adjust itself to the new condition. This acts practically the same as the flywheel does on a mechanical load."

MR. MARSHALL: "I think on the ordinary railroad the better class of power plants are already very well equipped and very well managed with everything to give economy of operation, but almost all of the railroads, that I know anything about, have got a large number of very inefficient smaller plants especially connected with the roundhouses. I cannot conceive of anything that is any less economical than a firebox boiler operated on a railroad. I have been urging for a number of years either to abandon these firebox boilers or else to design a regular brick furnace and use these firebox boilers merely as a heat absorbing device. So far I have not been able to get that idea over."

MR. BEBOUT: "A locomotive boiler was designed for locomotive service and not for stationary plants. We are trying to get away from the locomotive boiler in stationary plants."

MR. WINSLOW: "The question of bettering the combustion on a locomotive type boiler is rather difficult, but I have an idea that it might be improved by lining the firebox, which in its ordinary form is a very poor place for combustion on account of the cooling effect of the water jacket."

MR. MARSHALL: "In regard to the capacity of the firebox boiler, we have made tests and we find a 100 horsepower boiler will give us about 78 horsepower under the best possible operating conditions that we can put up for that test. Consequently if we do anything more to reduce the capacity we are out of luck. I had conceived the idea of putting the furnace under the boiler, elevating these boilers say five or six or even eight feet and then you can make as big a firebox as you like and you can get complete combustion before any of the flames touch any of the cooling surface."

MR. WINSLOW: "It is often a rather expensive arrangement to try to adapt a device of this sort, and I should imagine it would figure out cheaper to buy a new boiler."

THE PRESIDENT: "Gentlemen, the zero hour is approaching. It is here. There are other questions I am sure you would like to ask and probably other comments you would like to make. If you are agreeable it will be left to you to write your remarks to Mr. Winslow or to Mr. Andreucetti on this subject so that they will be included in the proceedings."

MR. MARSHALL: "I have heard a number of fellows say this has been the most successful, most businesslike meeting that we have ever had. I believe it is so myself. The exhibits have been especially fine. The convention has been better attended than ever before, and greater interest has been shown. I believe this is the most successful convention we have ever had and I believe no small part of it was due to the fact that we have had a very efficient man in the chair. I would like to have an expression of thanks offered to the president for the manner in which he has handled the proceedings."

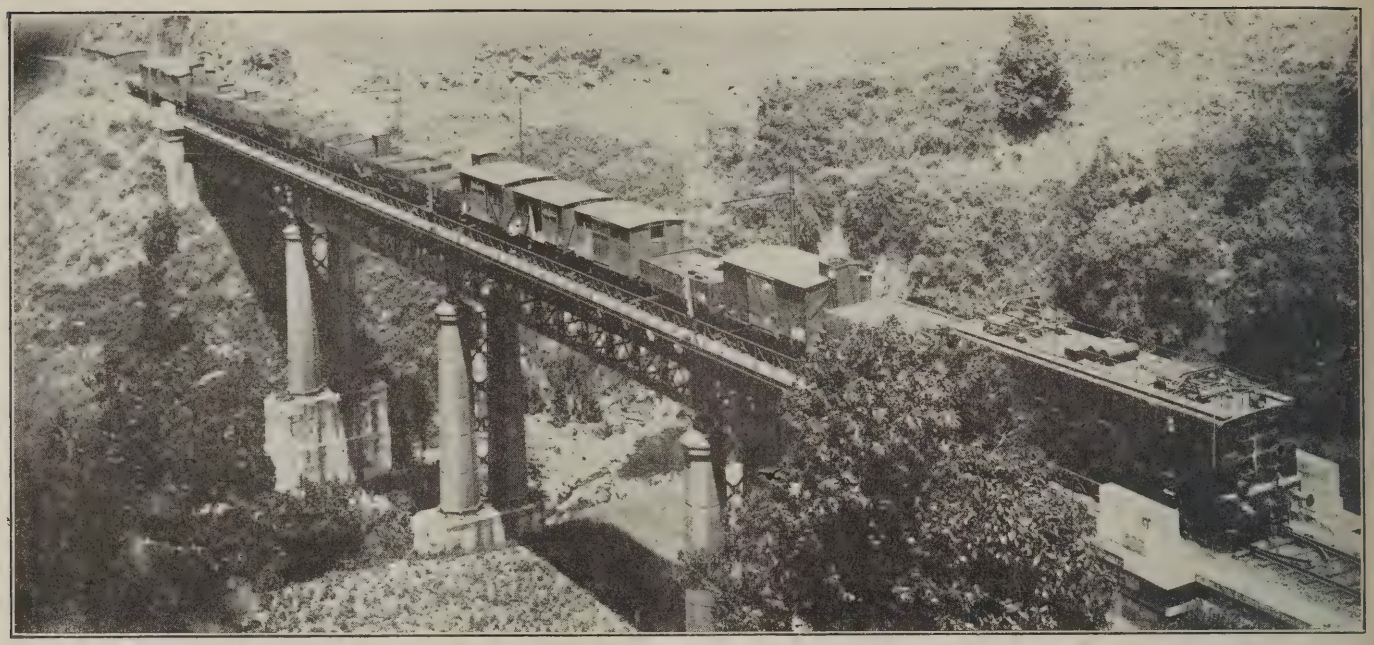
A rising vote of thanks was then unanimously extended to President Lunn. The meeting then adjourned.

Election of Officers

For the coming year the following officers were elected: F. J. Hill, president, Michigan Central; E. Wanamaker, first vice-president, Chicago, Rock Island & Pacific; C. R. Sugg, second vice-president, Atlantic Coast Line. J. C. McElree, Missouri Pacific, and G. H. Caley, New York, Ontario & Western, were elected as new members of the executive committee. The nominating committee will consist of J. R. Sloan, Pennsylvania Railroad; C. R. Gilman, Chicago, Milwaukee & St. Paul; E. Marshall, Great Northern; J. E. Gardner, Chicago, Burlington & Quincy, and E. Lunn, Pullman Company.

The officers which the Railway Electrical Supply Manufacturers' Association elected for the coming year are: George H. Scott, president, Safety Car Heating & Lighting Co., Chicago; E. A. Lundy, senior vice-president, E. A. Lundy Co., Cleveland, and W. Fenley, junior vice-president, Kerite Insulated Cable & Wire Co., Chicago.

Illinois Central Tracks, Chicago—Soon to Be Electrified



Freight Train Hauled by G. E. Locomotive on Bridge Near Fierros

The Spanish Northern Railway Electrification

New Motive Power is an Answer to Problems Presented by Tunnels and High Cost of Fuel

PRIOR to 1914 Spain received most of its coal from the British Isles, but during the late war shipments were greatly reduced and finally stopped entirely. The shortage caused by the cessation for foreign shipments was keenly felt by all the large cities in Spain, especially Madrid.

Mines were put in operation which before were considered unprofitable. Particularly was the product increased in the Asturias region in the Cantabrian mountains which parallel the north coast. The amount of coal which could be shipped to the center of Spain was limited by the capacity of the railways leading out of the region. In fact much of the coal is shipped north to the port of Gijon, whence it is transshipped by boat to other domestic ports.

The Northern Railway of Spain has a single track line from Gijon on the coast passing south through Oviedo and Leon and joining the main line from France to Madrid at Venta de Banos. The limiting feature of this line is the section between Ujo, which is 870 ft. above sea level, and Busdongo just over the ridge on the southern slope of the mountains, which is 4310 ft. above sea level, a total distance of 38.6 miles.

It is this section which is now being electrified, as the initial step of an extensive program. In this distance the road goes through 71 tunnels, with an aggregate length of 16.8 miles most of which is on curves. The longest tunnel La Perruca, a short distance north of Busdongo, is on tangent track and has a total length of 1.91 miles. The longest tunnel on the curved sections is El Orria, which is .66 miles long and makes about three-quarters of a complete circle.

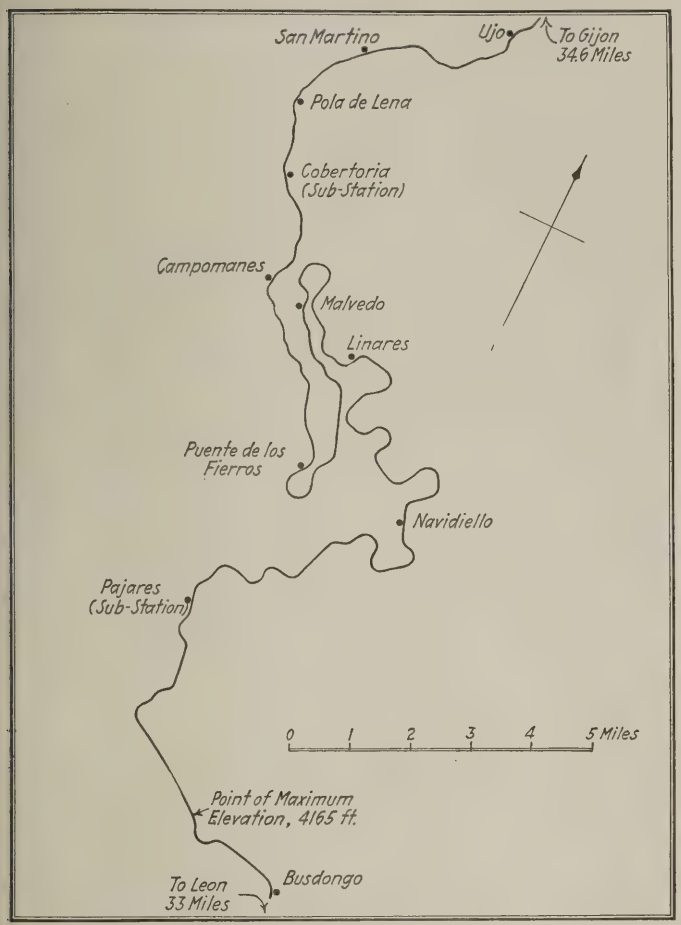
This unusual stretch of railway work was built about 40 years ago under the direction of a prominent Spanish engineer. Here in Spain, as in Russia, the width of the track gage is 5 ft., while in France and the rest of Europe the American standard of 4 ft. 8½ in. is almost universally used.

The initial contract for this electrification was awarded to the Sociedad Iberica de Construcciones Electricas, the representatives in Spain for the International General Electric Company, and provides for six 3000-volt locomotives, two 2-unit 3000 kw. substations and overhead line material for the complete project. In addition to the above, six additional locomotives have been ordered from the Westinghouse Electric & Manufacturing Company. For the present, power is purchased from the hydroelectric system of the Electra de Viesgo Company at 30,000 volts, 3-phase, 50 cycles. This energy is transmitted over the lines of the railway company to substations located at Pajares and Cobertoria.

The present schedule with steam operation consists of from 11 to 12 trains in each direction per day. It is expected that with the substitution of 12 electric locomotives for steam power the normal train movement can be considerably increased. This will release 28 steam locomotives for other service. The locomotives which the General Electric Company has constructed for this service are of the swivel equalized truck design and weigh 89.5 tons (81.4 metric tons), all on the driving axles. With this type the pulling stresses are transmitted through the platform of the locomotive instead of through the truck frames as is the case with the articulated type.

The cab is supported through center plates on two three-axle trucks. A. G. E. 255-B motor is geared to each of the six driving axles, giving a total capacity of 1550

horse power. Hauling a 330-ton train up the 2 per cent grade at a speed of 21.7 miles an hour requires a tractive effort of 22,000 lb. The maximum speed on level tangent track is 24.9 miles an hour with a train of 1500 tons,



Map of Electric Zone of the Spanish Northern Railway Between Ujo and Busdongo

while the maximum emergency speed of the locomotive is 37 miles an hour.

The auxiliary apparatus and control mechanism are housed in the box type cab which extends the full length of the locomotive. The platform is built up of structural steel members which are securely braced and riveted and covered by a steel floor ⅜ in. thick. At each end, an operating compartment for the engineer is partitioned off from the apparatus room in the center. Current is collected by either of two G. E. slider type air raised gravity lowered pantographs mounted on the roof.

When descending the grade, the locomotive is held back by regeneration, five of the motors becoming generators while the sixth generates their exciting current. The locomotives in addition are equipped with vacuum brakes which are only used in emergencies and in bringing the train to a complete stop. On this system, though practically all of the passenger coaches are equipped with brakes, the freight cars have only individual hand brakes which must be applied by the trainmen when a braking effort is required in excess of that necessary to slip the wheels of the locomotive. In actual freight service it is the practice to have a man stationed on every fourth car to be ready, if necessary, to assist in braking the train. At present an average freight train will consist of from 28 to 36 freight cars of 5 tons capacity, which requires a large crew.

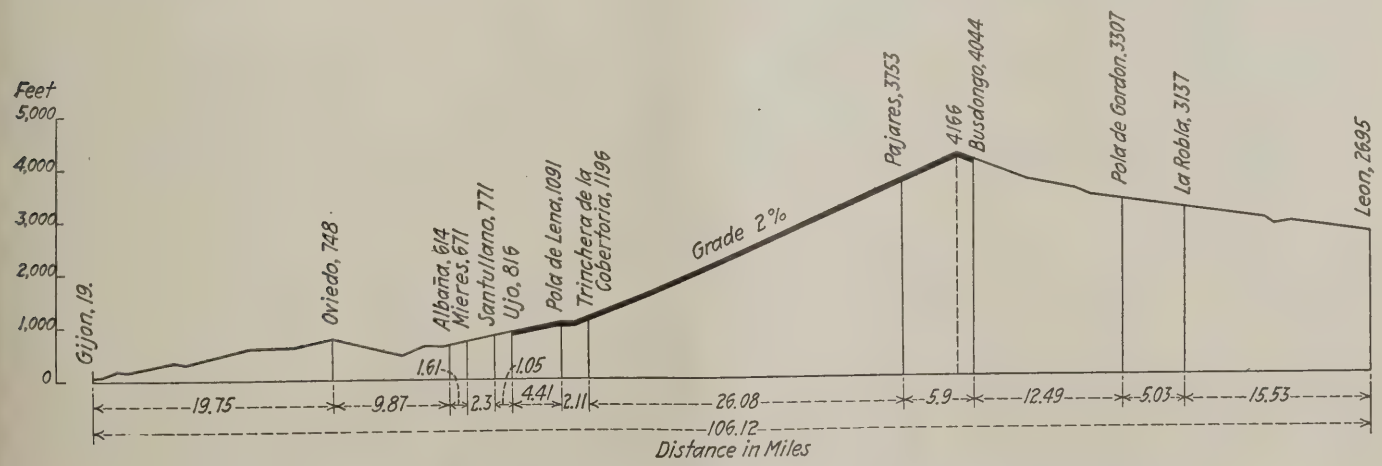
The normal train movement is "loaded" up-grade (from Ujo to Busdongo) and "empty" down-grade, although loaded trains up to rated capacity of the locomotive are also handled on the down-grade.

Ratings, Dimensions and Weights of Spanish Northern Railway Locomotives

Electrical Data	
Nominal voltage of system	3,000 volts
Tractive effort continuous	26,500 lb.
Tractive effort 1 hr. blown	27,100 lb.
Tractive effort at 30 per cent ccef	53,700 lb.
Total h.p. continuous	1,550
H.p. 1 hour	1,550
Speed continuous	21.9 m.p.h.
Speed 1 hour	21.6 m.p.h.
Number of motors	6
Type of motors	255-B
Gear ratio	4:1 or 72:18
Mechanical Data	
Track gage	5 ft. 6 in.
Width	9 ft. 8⅛ in.
Length	46 ft. 0 in.
Max. rigid wheelbase	11 ft. 6 in.
Dia. of drivers	39⅜ in.
Total wheelbase	35 ft.
Number of driving axles	6
Height over trolley locked down	13 ft. 5 in.
Weights	
On drivers (total weight)	179,000 lb.
Weight per driving axle	29,830 lb.
Weight of electrical equipment	85,000 lb.
Weight of mechanical equipment	94,000 lb.

Motors

The motors are of the commutating pole box type with the air inlet at the top. Ready access to the armature, pole pieces and field coils is provided through the pinion end. Large handholes allow easy inspection of the commutator and brushholders. The bearings are waste



Profile of the Gijon-Leon Division of the Spanish Northern Railway Including the Electric Zone

lubricated and an ample supply of oil is insured by auxiliary oil wells.

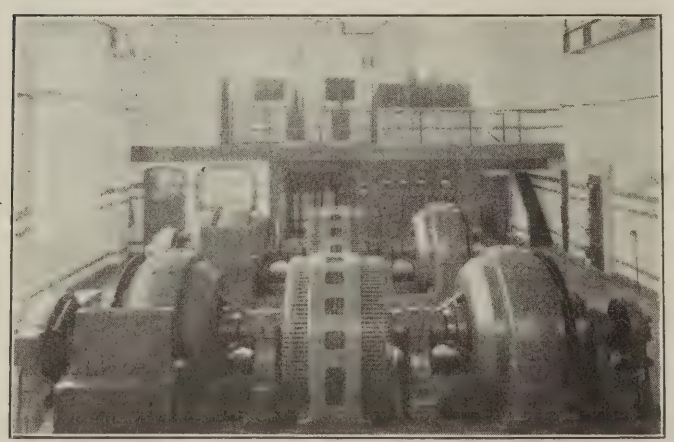
Louvres in the sides of the cab permit the entrance of air to the whole interior of the apparatus compartment. The blower drives the air into the horizontal duct between the center channels of the locomotive platform. These ducts open through hollow center plates and flexible duct connections into the truck transoms, which in turn connect with ventilating openings in the motors. The series method of ventilation is used, that is the air enters the top of the motor frame at the pinion end, is forced over the armature and field coils returning through the commutator and armature core to the pinion end, whence it is expelled through holes in the framehead. These motors are designed for operation at 1000 volts per commutator and are insulated to operate three in series on 3000 volts.

The motor has a continuous rating for 120 deg. rise by resistance of 258 hp. at 1000 volts. The gears and pinions are made of oil tempered steel and have a ratio of reduction of 72 to 18 teeth.

Control

The control is electro-pneumatically operated and is intended for non-automatic single unit operation with the following connections: One group of six motors in series, or two groups of three motors in series.

Fourteen steps are provided for acceleration with six motors in series, ten steps with the two groups of three in series connected in parallel, and thirteen steps in regenerative braking. In starting, the six motors are connected in series with the line and an adjustable resistance. This resistance is short circuited as the controller

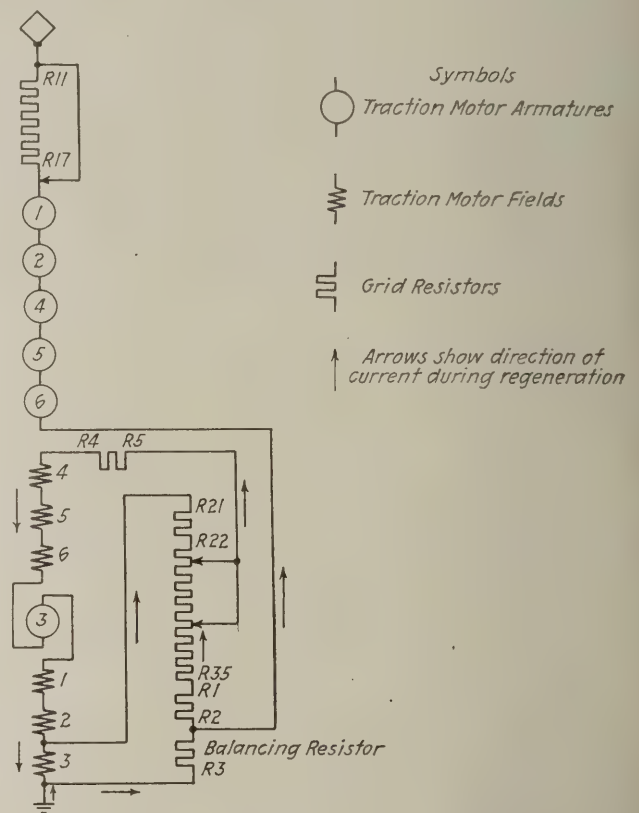


Interior of Cobertoria Substation, Showing Two 1500 Kilowatt Synchronous Motor Generator Sets, High Speed Circuit Breakers and Switchboards

is moved from point to point of the series position of the main handle until all the resistance is cut out and the motors are all in series directly across the line. Then as the accelerating handle is moved to the first series parallel notch of the controller, a pneumatically operated transfer switch reconnects the motor circuits into the series connection with the resistance again in series. The operation is then repeated until the motors are in full series-parallel position.

All the motor switching is performed by air operated contactors which short circuit the resistance. They are closed by air confined in a cylinder operating against a piston, and opened by the action of a heavy spring against the piston. An arc chute and blower coil insure proper rupturing of the arc. An electro-pneumatically operated reverser is interlocked with the line contactors.

For speeds above the full series and full parallel connection, two reduced field positions are provided by means of which the motor speed is increased. Both reduced field positions can be obtained in either of the full running positions, this is accomplished by moving a selective handle on the master controller. This controls contactors



Schematic Diagram of Regenerative Braking Connections for Locomotive, Self Excitation

which connect an inductive shunt across the field. In emergencies three of the motors may be cut out and the locomotive operated with the remaining three.

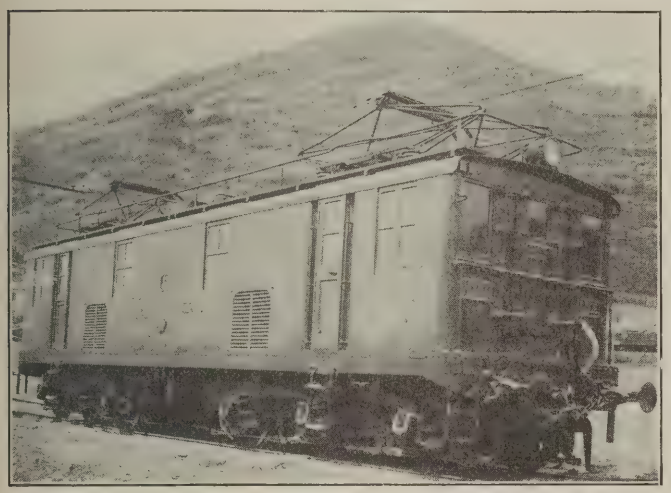
Regeneration is accomplished by using one motor for exciting its own field and the fields of the other five motors. The remaining five motors are connected in series and regenerate to the line in proportion to the field excitation. Only one combination of motors is used for regeneration, but by means of the thirteen steps which are provided, a speed range of from 12.5 miles an hour to maximum operating speed of the locomotive is obtained.

The regenerative braking employs the same controller, contactors, and resistors as are used during motoring. This means simplicity of control and economy of apparatus. A balancing resistance is used for the protection of the motors to stabilize the excitation and to compensate against line voltage changes. When starting to regenerate, the main handle of the master controller is moved to the off position, and the selective handle then thrown to the braking connection. The same handle is used to select the motoring, reduced field and the regenerative braking connections. Upon setting the selective handle for the braking connection, a transfer switch

is thrown by means of a pneumatic cylinder. This rearranges the circuits to give the connection necessary for regenerative braking. The main handle may then be notched up until the desired braking torque is obtained. The master controller is mechanically interlocked so that no false manipulation is possible.

Auxiliary Equipment

Power for the operation of the control circuits, lights, cab heaters, air compressor, exhausters and for charging



One of the 90-Ton, 3000-Volt Electric Locomotives. Built by the General Electric Company

the storage battery is furnished by a 10 kw. 65-volt generator directly connected to a 25 hp. 3000-volt motor. A blower mounted on the extended shaft of the motor generator set furnishes air for the ventilation of the traction motors.

As a reserve a storage battery of a capacity sufficient to operate the control, an exhauster and the lighting system for one hour is provided. A reverse current relay is placed in the circuit between the battery and the generator to prevent the discharge of the battery.

The compressor, which furnishes air for the control, pantograph, whistles and sanders, is operated from the 65-volt circuit and is controlled by a governor which starts or stops the compressor automatically, thereby maintaining the pressure between certain predetermined values.

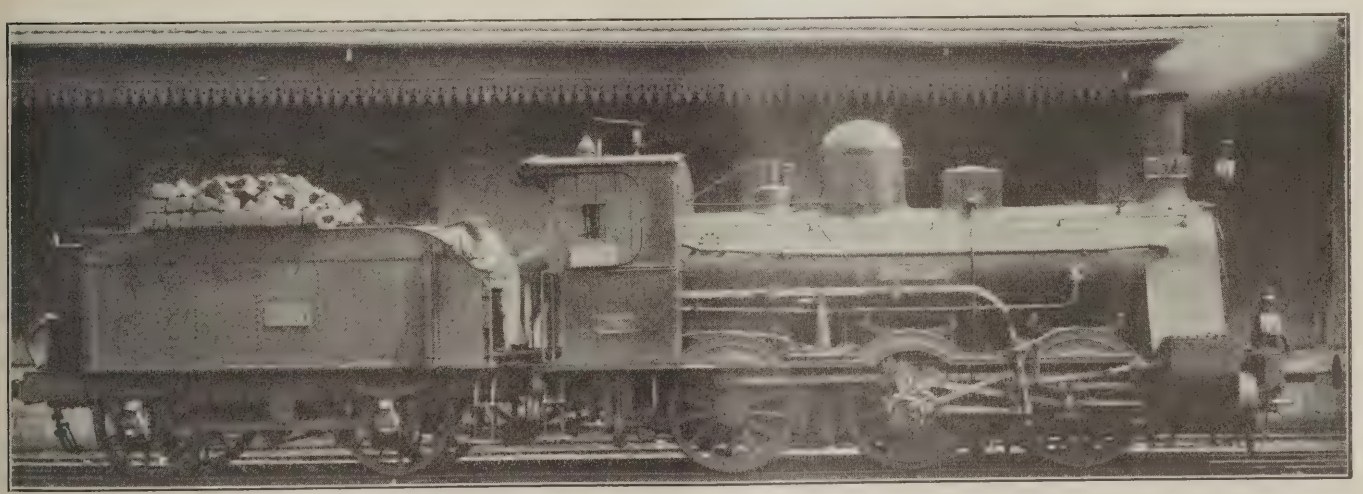
Two exhausters, both of which operate from the 65-volt circuit, supply the vacuum brake system on the locomotive and the passenger coaches. One exhauster operates normally at slow speed, while the other is normally shut down.

A high speed circuit breaker is connected ahead of all other apparatus in the main motor circuits. In case of short circuit on any part of the apparatus, or a heavy overload, the circuit breaker trips and opens the circuit. The high speed with which the breaker opens greatly reduces the liability of damage from either short circuits or heavy overloads. In addition to protecting the locomotive it also protects the generating units in the substation by quickly reducing any heavy power demands due to grounds or overloads. The breaker has no mechanical latches or triggers. It is tripped electromagnetically. The blow-out consists of a powerful magnetic field which combined with the narrow arc chute quickly breaks the arc caused by opening the circuits An overvoltage relay is connected across the regenerating motors in series with the high resistance, and is arranged so that when the motors generate a predetermined voltage this relay opens, tripping out the high speed circuit breaker and dropping out the resistance contactors during regeneration so as to open the field of the motors. This furnishes protection against overvoltage in case of loss of trolley or substation.

Substations

Power from the 30,000-volt lines is converted to 3000 volts direct current in two substations, one of which is located at Cobertoria 6 miles from Ujo; the other is at Pajares which is the same distance from Busdongo, the southern end of the electric zone.

Each of these stations contains two, three-unit, four-



Type of Steam Locomotive Used on Passenger Trains. Weight on Drivers is Approximately 90,000 Pounds

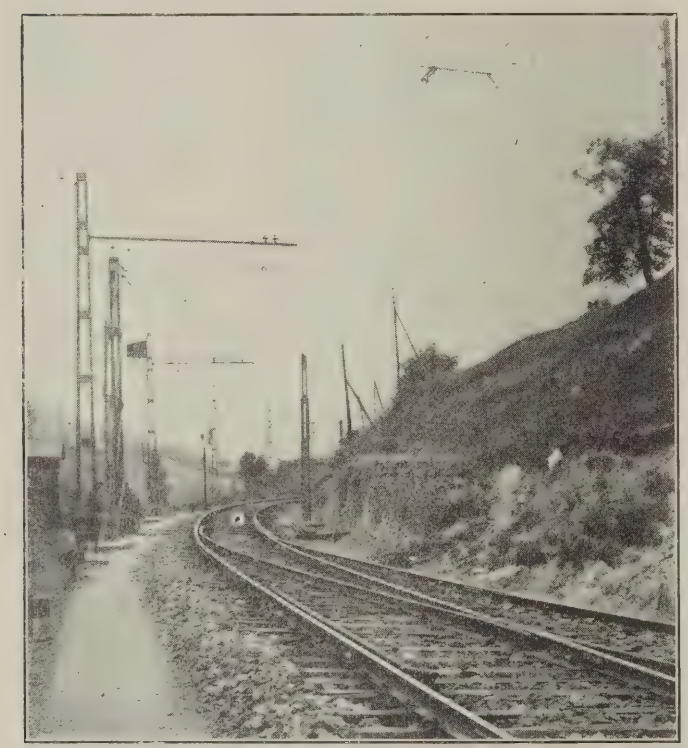
bearing 1500 kw. 3000-volt d. c. motor generator sets with the necessary transformers and switch gear. Provision is made for the future installation of a third unit in each station. The outgoing positive feeders are amply protected by the addition of high speed circuit breakers located in each line.

Two three-phase oil-cooled transformers rated 30,000/

3500 V., 1900 kv-a, 50 cycles are installed in each of the two substations. Four 2½ per cent taps are provided in the low voltage winding to compensate for variation in the transmission line voltage and 50 per cent starting taps for starting the motor generator sets.

The direct current generators are designed for 1500 volts per commutator and are permanently connected in series for 3000-volt operation. They are separately excited from a small 125-volt generator mounted on one end of the set. The series field of each main generator is designed to provide flat compounding from no load to 50 per cent overload. They are equipped with commutating poles and compensated windings to insure sparkless commutation under all load conditions.

Excitation for the synchronous motor is provided by a second 35 to 150-volt direct current generator placed on the opposite end of the set. It has a series winding which carries the 3000-volt line current so that the motor field excitation varies in proportion to the load on the set. This insures correct power factor with varying loads, and also insures stable operation under heavy overloads. These sets handle 150 per cent load for 2 hours; 300 per cent load for 5 minutes. They also operate inverted to take care of regeneration.

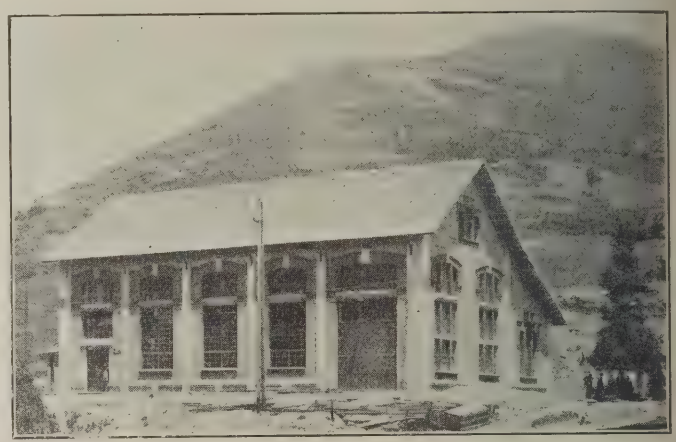


Overhead Construction at the North End of Campomanes Yard, Showing Line, Anchor Poles, Sectionalizing Switch, and in the Distance the Station Signal

Overhead Line Construction and Bonding

The overhead construction is of the modified flexible catenary type designed by the General Electric Company and installed under supervision of the S. I. C. E. Co. This overhead is known as the twin catenary type and comprises two 4/0 copper wires flexibly suspended side by side from the same ½-in. diameter steel messenger by independent loop hangers. These supports are spaced 15 feet apart and are alternately connected to each contact wire. Thus the distance between adjacent hangers is 7½ feet. With this construction, due to the four contacts secured by the double pantograph collector and the twin trolley wire, current is collected under all conditions without visible sparking. Porcelain insulation is used throughout. Steel poles spaced at intervals of 150 feet on tangent track with reductions on curves support the brackets carrying the messenger. Brackets on the poles carry the positive feeder and the negative return wire, while in the tunnels these are carried on iron bracket supports.

It is possible on account of the unusually circuitous route which the track follows to improve the distribution by running the feeder across the ends of several loops which are made necessary to conform to the limiting grade. One of these cut-offs is 1.25 miles in length cutting off about 4.5 miles while two others about 0.3 miles in length join the ends of another loop of about the same length.



The Cobertoria Substation

As it was deemed advisable to put in concealed bonds, it was necessary to install special fish plates throughout the electrified section.

Each rail joint is bonded by 12-in. 4/0 copper bonds, and every 1000 feet a 4/0 steel cross bond 76 in. long is put in.

To protect the system, sectionalized construction is used. Due to the character of the country, the mountains, curves and tunnels, and the fact that normal operation of the railroad must not be interfered with, all construction was done at night. The copper wire used in the work was drawn and stranded at Cordoba, a noted manufacturing center in the south of Spain. Officials of the Spanish Northern Railway designed and installed the substations and overhead line material. In this work they were assisted by the engineering staff of the S. I. C. E.

Compendium of Automobile Stop-Laws

Laws and rules regulating the management of automobiles in approaching railroad crossings is the subject of a pocket-size pamphlet of 48 pages which has been prepared by the Association of Railway Claim Agents; extracts from the statutes and the orders of public commissions in each of the states of the Union where action of this kind has been taken. The pamphlet is issued by the secretary of the Association, H. D. Morris, Northern Pacific Railway, St. Paul, Minn.

Chicago as It Now Looks North of the Loop District—P & A Photo

R. E. S. M. A. Exhibitors at A. R. E. E. Convention

Space Occupied by Exhibits Was Forty Per Cent Greater This Year Than in 1923

THE exhibits presented by the Railway Electrical Supply Manufacturers Association at the fifteenth annual convention of the Association of Railway Electrical Engineers this year were the largest and best ever presented at this convention. In previous years all of the exhibits have been placed in the ball room of the La Salle Hotel, Chicago, while the A. R. E. E. meetings were held in the red room on the same floor. This year the red room was given over to exhibit space, and was completely filled; the A. R. E. E. meetings were held on the mezzanine floor. Contrary to expectations, the separation of the meetings and the exhibits did not detract from the attendance at either one. The fact that all the available new space was filled, however, indicates that it will probably be necessary to find more room for the exhibitors in 1925.

Election of Officers

At the meetings of the Railway Electrical Supply Manufacturers Association held on Thursday morning, October 23, the following officers were elected for the coming year:

President, George H. Scott, Safety Car Heating & Lighting Company, Chicago; senior vice-president, E. A. Lundy, E. A. Lundy Company, Pittsburgh; junior vice-president, W. H. Fenley, Kerite Insulated Wire & Cable Company, Chicago secretary and treasurer, Edward Wray, Railway Purchases and Stores, Chicago. Executive committee John McC. Price, Industrial Controller Company, Chicago; W. F. Bauer, Edison Storage Battery Company, Chicago; Otis B. Duncan, Western Electric Company, Chicago; R. N. Baker, Central Electric Company, Chicago; R. I. Baird, Electric Storage Battery Company, Chicago; Charles Dubsky, Crouse Hinds Company, Chicago; W. A. Ross, Oliver Electric Company, Chicago; F. M. Condit, Fairbanks Morse Company, Chicago; R. H. Kilner, Westinghouse Electric & Manufacturing Company, Chicago.

Exhibitors, Their Products and Representatives

The following is an alphabetical list of the manufacturers having exhibits at the convention together with brief descriptions of the products shown and the names of the representatives present:

Adams & Westlake Company, Chicago, Ill.—Coach, Pullman and mail car lighting fixtures flashing relays in operation with case removed; signal lamps; fans and flush type switches; electric hand lanterns and an electric car inspector's lantern; a flashing railroad crossing signal in operation, and a red warning signal also in operation. Represented by A. S. Anderson, E. H. Leisch, Wm. J. Pierson, Wm. G. Porter, H. G. Turney, G. L. Walters, Chicago.

Ahlberg Bearing Company, Chicago, Ill.—Holman single and double row annular bearings and Ahlberg ground bearings. Represented by W. C. Bender, D. A. Campbell, B. B. Clark, H. E. Dunning, W. F. Fries, C. W. Pearsall, Chicago.

Louis Allis Company, Milwaukee, Wis.—Direct current motors and alternating current motors complete and disassembled featuring the one-piece "indestructible" copper squirrel cage rotor manufactured by this company. Represented by Wm. S. Burr, R. W. Brewer, E. B. Fogelsong, Chicago.

Albert & J. M. Anderson Mfg. Co., Boston, Mass.—Automatic time switches; large capacity disconnecting switches and knife switches; plugs and receptacles of all capacities for battery charging, welding circuits and locomotive wiring. Represented by B. G. Durham, Chicago.

Appleton Electric Company, Chicago.—Complete line of conduit fittings (Unilets); "Reelite" and "Mogul Reelite" take-up reels; outlet boxes, switch boxes and steel fittings. Represented by J. T. McHenry, A. S. Merrill, E. A. Hokanson, Chicago.

Baker R. & L. Company, Cleveland, Ohio.—A full size drive axle unit such as is used on all models of Baker

trucks with representative photographs showing all types of such performing operation in railroad service. Represented by M. A. Watterson, Frank N. Phelps, Cleveland, Ohio; Harry Greig, T. W. Barnes, W. F. Hebard, V. A. Shouldis, Chicago.

Benjamin Electric Mfg. Co., Chicago.—Locking socket for preventing lamp theft; dust tight heavy duty glass cover for R. L. M. reflectors; vapor proof lighting unit with reflector for oil houses fibre groundless hand portables; spring-type shock absorbing fixture aligner. Represented by P. A. Powers, W. I. Goodrich, F. H. Bendeich, Jr., Chicago.

I. A. Bennett & Co., Chicago.—A rack showing "Sheraduct" conduit in all stages of manufacture from raw material to the finished product; samples of 5/16-in. 2 and 3 wire "Ovalflex" cable for coach wiring; three exhibit boards showing boxes, bushings, connections, "Sheraduct" and "Economy" conduit and "Flexsteel" cable and conduit. The exhibit also included a 6¼-in. spiral coil made by wrapping a 10-ft. length of ½-in. "Sheraduct" around a 6-in. cedar post. Represented by A. E. Provost, J. C. Wagemann, R. C. Bennett, Chicago.

Bryant Electric Company, Bridgeport, Conn.—Wiring devices, including plugs, fuses, receptacles, sockets, switches, marine devices, heater controls and pilot lamp combinations. The pilot lamp combinations were connected so they could be shown in operation. Represented by W. A. Stacey, Ward Thomas, W. O. Dahlstrom, C. W. Foster, H. W. Freese, Chicago.

The Buda Company, Harvey, Ill.—A 500-watt turbo-generator set for locomotives shown with quarter section removed and painted in colors inside to show steam and oil passages. Represented by H. P. Bayley, Harvey, Ill.

Bussman Mfg. Co., St. Louis, Mo.—Fuses of all types. Represented by Martin J. Wolf, Geo. L. Delany, St. Louis, Mo.; C. L. Steber, J. C. Ingram, H. F. Williams, Chicago.

Central Electric Co., Chicago.—"Okonite" wires, cables and tape; "Maxolite" reflectors; "Attalite" units; "Ralco" receptacles and plugs; electrical fittings for cars and locomotives; panel boards; car fixtures; connectors; specialties. Represented by A. L. McNeill, E. H. McNeill, R. N. Baker, J. M. Lorenz, J. J. O'Brien, Chicago; L. R. Mann, St. Louis, Mo.

Chicago Fuse Mfg. Co., Chicago.—"Union" renewable and non-renewable enclosed fuses; "Gem" non-indicating fuses and plugs; "Union" outlet boxes and covers; "Gem" sectional switch boxes. Represented by H. P. Collins, C. W. Beach, Tom Walsh, Chicago.

Crouse-Hinds Co., Syracuse, N. Y.—"Condulets"; safety switches; flood lights; panels and cabinets; traffic signals. Represented by A. F. Hills, C. H. Bissell, F. C. Smith, E. G. Smith, Syracuse, N. Y.; H. J. MacIntyre, New York; H. D. Rei, Pittsburgh, Pa.; A. B. McChesney, Detroit, Mich.; E. F. Skeel, B. J. Underwood, Charles Dubsky, E. F. Ganzow, N. E. Bigley, E. C. Otto, W. W. Booth, Chicago; J. B. Wilmott, St. Louis, Mo.; A. E. Vieau, Minneapolis, Minn.; H. W. White, Philadelphia, Pa.; H. R. Johns, Toronto, Can.; D. A. Nespitt, Cleveland, Ohio.

Cutter Electrical & Mfg. Co., Philadelphia, Pa.—Four models of "U-Re-Lite" circuit breakers mounted on a slate panel including capacities for both direct and alternating currents from 200 to 400 amperes, in a line which is made in capacities to 1,200 amperes direct current, and is being developed to 1,250 amperes alternating current. Represented by E. Swift Newton, Philadelphia, Pa.; O. M. Bercaw, I. S. Allen, Chicago.

Direct Sales Company, Chicago, representing the Martindale Electric Company, Cleveland, Ohio.—"Imperial" commutator stones; "Imperial" commutator cement; "Imperial" commutator grinding tool; "Imperial Blow-er Clean" portable blower for cleaning electrical machines; hand and motor driven commutator slotting equipment; "Commulac," a special insulating varnish for painting commutator slots to prevent short circuits; "Efficiency" refillable plug fuses. Represented by W. R. Pflasterer, Chicago; E. H. Martindale, Cleveland, Ohio.

Dodge Manufacturing Corp., Oneida, N. Y.—Dodge-Timken roller hanger bearing countershaft; Dodge wood rim motor pulley with interchangeable center which is secured to shaft by compression; Dodge-Timken roller bearing spherical ball and socket pillow block; an 18 in. by 28 in. crown face barrel type axle pulley; an 18 in. by 10 in. axle pulley of new design with a disc center; a standard 18 in. by 10 in. Oneida axle pulley; an 18 in. by 10 in. Oneida axle pulley with new design of rim fastener. Represented by F. M. Young, A. W. Nafziger, Chicago; E. G. Richards, Oneida, N. Y.

Edison Storage Battery Co., Orange, N. J., and Railway Storage Battery Car Co., New York.—Edison Nickel-Iron-Alkaline storage batteries; model of Railway Storage Battery Car Company's battery car. Represented by W. F. Bauer, A. M. Anderson, O. A. Neidermeyer, U. W. McMillan, Chicago; D. C. Wilson, Orange, N. J.; R. C. Haley, St. Louis, Mo.; D. B. Mugan, New York; J. L. Hays, Washington, D. C.; L. Klopman, N. Y.

Electric Controller & Mfg. Co., Cleveland, Ohio.—Squirrel cage motors and alternating and direct current control equipment including compensators, starters, relays, float switches and pressure regulators. Represented by R. G. Widdows, Cleveland, Ohio; E. C. Ryan, A. J. Waltz, R. E. Bock, J. F. Elliott, Chicago.

Electric Service Supplies Co., Philadelphia, Pa.—A locomotive headlight generator driven by a motor with section cut away and replaced with glass to show oil circulation; a standard headlight generator; five different models of locomotive headlights with copper, sheet steel and aluminum cases; golden glow reflectors; floodlights; roundhouse lighting units; a new type of classification and marker lamp; Segur coil winding and forming tools. Represented by J. W. Porter, J. C. Bryan, B. D. Barger, T. M. Childs, Chicago; H. J. Graham, E. G. McAllister, Philadelphia, Pa.

Electric Storage Battery Co., Philadelphia, Pa.—A complete 3 kw. constant potential axle light equipment shown in operation; "Exide Gummite" containers "Exide Iron Clad" industrial batteries for trucks, tractor and industrial locomotives; train control batteries; radio batteries. Represented by R. I. Baird, G. H. Atkin, T. Milton, C. L. Bend, E. W. Wilson, J. W. Tierney, R. S. Marriner, Chicago; W. H. Payne, T. P. O'Malley, St. Louis, Mo.; J. N. Rosholt, Denver, Colo.; P. G. Downton, J. D. Fischer, Minneapolis, Minn.; H. B. Hamilton, Cincinnati, Ohio; J. A. Gould, Kansas City, Mo.; Thos. L. Mount, E. Watkins, Philadelphia, Pa.; H. S. Folk, H. G. Mills, New York; G. V. Cripps,

Cleveland, Ohio; L. E. Lighton, Detroit, Mich.; A. E. Wilkes, Toronto, Canada.

Fairbanks, Morse & Company, Chicago.—Sectionalized ball bearing type squirrel cage type H induction motor; type C C O R starting compensator for squirrel cage motors; a squirrel cage; a stator core assembly; a new type of bearing puller for removing ball bearings from motor shafts designed to transmit pulling pressure to inner bearing race. Represented by P. H. Gilleland, F. J. Lee, D. K. Lee, George Lewis, Chicago; E. E. Pendray, E. J. Coverdale, H. E. Vogel, E. P. Chase, New York; H. Kessel, Indianapolis, Ind.

Gamewell Company, Newton Upper Falls, Mass.—"Positive, Non-interfering" fire alarm boxes and general alarm apparatus such as would be used for a complete fire alarm system in industrial plants and railroad shops. The apparatus was in working order and connected to electrical circuits to show actual operation. Represented by F. H. Wright, Pittsburgh, Pa.; F. N. Adams, Chicago; G. Morley, Detroit, Mich.

General Electric Co., Schenectady, N. Y.—A cut section model of a General Electric headlight generator; a type "KT-900" series motor; a time limit acceleration starting compensator; an automatic primary resistance starter for squirrel cage induction motors; a "C R 4033-A 5" automatic starter for series, shunt or compound wound constant speed direct current motors; a motor-generator battery charging set for delivering a taper charge to truck and tractor batteries; type "T E S form B" panelboards equipped with tumbler type switches having heavy moulded insulated handles; an electric glue pot; a 30-lb. self-regulating melting pot; an "L-22" long range floodlight for yard lighting; an "L-15" floodlight with wide beam spread; a highway lighting unit; a Sprague hoist; an arc welding set for manual or semi-automatic operation; wire and cable and conduit products; a turbine for mechanical drive; insulating material; fusible primary cut-outs. Represented by John Roberts, C. C. Bailey, C. T. McLoughlin, Schenectady, N. Y.; C. Dorticos, W. M. B. Brady, W. G. Ferguson, Chicago; F. P. Jones, Philadelphia, Pa.; R. L. Hughes, St. Louis, Mo.; Lynn Covey, Cleveland, Ohio.

Gould Storage Battery Co., New York.—A 1-kw. slow-speed car lighting generator; a 4-kw. slow-speed car lighting generator; a 3-kw. high-speed car lighting generator mounted on a body type suspension; a combination generator regulator and lamp voltage controller for baggage cars and coaches; a standard B B 9-generator regulator; an "M-2" lamp regulator a "B B-10, Universal" generator regulator; an "M-4," 75-ampere heavy duty lamp regulator; an alternating current turbo-generator for locomotive lighting; a Gould train lighting battery; hard rubber battery jars (self-sealing and plain). Represented by G. R. Berger, Chicago; W. F. Bouche, E. J. Blake, M. R. Shedd, Depew, N. Y.; P. H. Simpson, New York.

Hazard Manufacturing Co., Wilkes-Barre, Pa.—Hazard wires and cables. Represented by H. B. Pflasterer, Chicago; L. W. Allen, New York; T. A. Keefe, Pittsburgh, Pa.

Howell Electric Motors Co., Howell, Mich.—A line of "Red Band" motors built with recentering bearings and double cotton covered enameled wire. Represented by C. F. Norton, P. A. Arndt, Howell, Mich.; O. A. Reed, J. M. Johnson, D. S. Wilkus, Chicago.

Industrial Controller Co., Milwaukee, Wis.—Automatic direct current starters; automatic alternating current across-the-line type starters; automatic and manually operated compensators. Represented by John McC. Price, Earle J. Rooker, Chicago.

Kerite Insulated Wire & Cable Co., New York.—Kerite wires and cables. Represented by B. L. Winchell, Jr., Azel Ames, P. W. Miller, New York; W. H. Fenley, J. A. Hamilton, E. L. Adams, C. A. Reeb, C. E. Hieber, E. M. Branchfield, M. D. Cook, Chicago.

Krebs Mfg. Co.—The Krebs universal self-aligning pulley. Represented by C. E. Krebs, W. O. Tate, Chicago.

Lincoln Electric Co., Cleveland, Ohio.—A 1925 model of Lincoln "Railroad" arc welder; welding accessories; four alternating current motors from 1 to 60 hp.; a 1 hp. motor running submerged in a glass tank of water. Represented by R. A. Davidson, A. H. Homrighaus, J. E. Durstine, C. R. York, L. W. O'Day, Chicago; R. E. Kinkead, Cleveland, Ohio.

Loeffelhoelz Company, Milwaukee, Wis.—Gibbs train connectors; receptacles, plugs and accessories; berth lamps. Represented by L. R. Taylor, G. B. Miller, P. A. Bernhardt, Milwaukee, Wis.

E. A. Lundy Co., Pittsburgh, Pa., representing Chicago Insulated Wire & Mfg. Co., Sycamore, Ill.; Illinois Electric Porcelain Co., Macomb, Ill. Line Material Co., South Milwaukee, Wis.; Reinforced Switch & Mfg. Co., Pittsburgh, Pa.; Fansteel Products Co., North Chicago, Ill.—High and low tension line material; fuses; disconnecting switches; wire; electrolytic rectifiers; wet and dry process porcelain insulators; rail bonds; outdoor lighting units; fuse clips. Represented by Preston Parish, Chicago; P. M. Etters, Philadelphia, Pa.; E. A. Lundy, Pittsburgh, Pa.

Mercury Mfg. Co., Chicago.—A new triple internal "Type H" gear drive unit shown in operation with wheel disc plate replaced by a glass plate to show the operation of the gears; a complete "Type H" Mercury tractor featuring an improved safety controller. Represented by H. B. Clapp, Winslow Hikle, W. H. Odiorne, Chicago.

Mutual Electric & Machine Co., Detroit, Mich.—"Bull Dog Luminized" safety switches and panel boards. Represented by E. A. Printz, J. E. Schwarz, Chicago; G. R. Watson, New York.

National Safety Appliance Co., Chicago.—A full size working exhibit of the National Train Control. Represented by K. E. Kellenberger, J. P. Robinson, E. C. Wilson, E. W. Stone, J. C. Anderson, Chicago.

National Lamp Works of the General Electric Company, Cleveland, Ohio.—Incandescent lamps. Represented by C. R. Stover, H. H. Helmbright, Cleveland, Ohio.

Okonite Company, Passaic, N. J.—Wire and cables including a recently developed train control wire; tape. Represented by F. G. White, J. W. Hackett, New York.

Oliver Electric & Mfg. Co., St. Louis, Mo.—Junction and terminal boxes, switches, plugs and receptacles for locomotive, car lighting, train control, shop lighting and yard battery charging wiring installations; signal lights and cab lighting fixtures for locomotives; safety switches for welding machines; a portable electric cast aluminum trainman's hand lantern. Represented by J. A. Amos, W. M. Graves, St. Louis, Mo.; W. A. Ross, Chicago; G. V. Wright, New York.

Pyle National Company, Chicago.—Turbo-generators in capacities from 500 watts to 7,500 watts for locomotive lighting, train lighting, and train control; a panel board

for use with headlights in train lighting when a turbine-generator is placed on the locomotive and auxiliary batteries are used; locomotive accessories; a complete line of flood lighting units including a 23-in. glass reflector with visor for illumination of railroad yards. Represented by J. Will Johnson, William Miller, T. P. McGinnis, P. S. Westcott, George E. Haas, W. T. Bretherton, Charles W. Dake, J. J. Kennedy, J. V. Baker, R. S. Parsons, Chicago; Crawford P. McGinnis, New York.

Railway Electrical Engineer, New York.—A miniature railroad in operation so arranged as to illustrate the different branches of railroad electrical work served by the magazine. The various parts of the exhibit illustrated "Power," "Illumination," "Heavy Electric Traction," "Train Lighting," "Electric Welding." Represented by Alfred G. Oehler, Charles J. Corse, New York; George Daves, R. F. Kenrick, Chicago.

Railway Utility Company, Chicago.—Honeycomb ventilators for railway passenger cars; electric heaters and heat regulators; a demonstration showing the 400 per cent overload capacity of the heating units. Represented by E. J. Magerstadt, Wm. J. Pine, E. G. Magerstadt, R. R. Holden, Albert Hirsch, C. L. Haas, N. L. Willer, Wm. G. Hartwig, Chicago.

Safety Car Heating & Lighting Co., New Haven, Conn. —Ten different types of car lighting fixtures; a 3-kw. and a 4-kw. axle drive generator with off-center and center suspension, respectively; two complete car lighting regulator panels; one Pullman generator regulator panel; ceiling, wall and exhaust type car-lighting fans; an electric water heater; a Putnam storage battery. Represented by J. H. Rodger, C. A. Pinyerd, Geo. H. Scott, Geo. D. Ladd, Chicago; A. L. Livingston, New Haven, Conn.; J. S. Henry, H. K. Williams, New York; S. I. Hopkins, C. A. Chasey, St. Louis, Mo.; C. W. T. Stewart, Philadelphia, Pa.

Simplex Wire & Cable Co., Boston, Mass.—Wires and cables, featuring "Tirex" portable cords and "Tirex" cables. Represented by H. R. Hixson, W. F. Hruby, L. S. Jones, J. N. MacAlister, A. Hagen, Chicago; W. I. Middleton, Boston, Mass.

S. K. F. Industries, Inc., New York.—Complete line of S. K. F. self-aligning ball and roller bearings; Hess-Bright deep groove bearings; S. K. F. thrust bearings; a roller bearing main journal box for Canadian Pacific passenger coaches. Represented by J. B. Castino, H. A. Gumm, Chicago.

Strom Ball Bearing Mfg. Co., Chicago.—A Pyle-National headlight generator with casing removed to show installation of Strom ball bearings; a 10 hp. induction motor with upper half of stator removed and one end of the shaft equipped with fan blades, the rotor being kept in motion by a breeze from a small electric fan; ball bearings of all sizes and types for car-lighting generators and other equipment; a board on which were mounted photographs and specimens showing the process of manufacture of a Strom ball bearing through production from the raw material to the finished product. Represented by Cora C. Smith, C. V. Johnson, Chicago.

Sunbeam Electric Manufacturing Company, Evansville, Ind.—A "type R. E. 3" 500-watt headlight generator embodying special features for train control service, with quarter section removed to show construction; parts display of the "R. E. 3" generator; "Sunbeam" airtight headlight with rustproof steel case; glass reflector headlights in several styles and sizes. Represented by J. Henry Schroeder, Evansville, Ind.; W. T. Mahogue, Philadelphia, Pa.; H. A. Varney, Chicago.

Square D Company, Detroit, Mich.—A line of Square D safety switches in sizes ranging from 30 to 1,200 amperes capacity; a Wigginton voltage tester. Represented by C. W. Bates, R. J. Parisian, Chicago.

Thompson Electric Co., Cleveland, Ohio.—A "Thompson safety lowering switch" for large overhead lamps mounted to show operation of lowering for cleaning reflectors and renewing lamps; accessories; drawings illustrating railroad applications of the "safety lowering switches." Represented by A. J. Thompson, Cleveland, Ohio; B. F. Webb, Chicago.

Transportation Engineering Corp., New York.—A complete line of Wanamaker coated electrodes including a coated manganese electrode which is being used for building up manganese frogs, crossings, etc., on steam and electric railroads and a coated bronze electrode used for arc welding on brass, copper and cast iron; "Tecor" electrode holders; a sand blast; welding lenses; shields and helmets; "Rexo" copper coated oxy-acetylene welding rods exhibited as a new product; samples of welding work on steel rails, manganese crossings, frogs, etc. Represented by F. V. McGinness, H. W. Stortz, New York; K. R. Hare, Chicago.

Trumbull Electric Mfg. Co., Plainville, Conn.—Safety enclosed electric switches ranging in capacity from 30 to 400 amperes; a practical demonstration of a new type of motor starting switch to show the operation of the switch under actual overload, undervoltage and phase failure conditions. Represented by B. Hallberg, C. E. Coe, M. L. Spaulding, Chicago.

U. S. Light & Heat Corp., Niagara Falls, N. Y.—A U. S. 200-amp. a.c.-d.c. portable welder; a car-lighting generator regulator; a "Type B" lamp regulator; a "Type C" lamp regulator with new type of diverter. Represented by H. A. Mathews, W. L. Bliss, Niagara Falls, N. Y.; W. F. Gunn, New York; O. R. Hildebrant, Norfolk, Va.; H. A. Morrison, H. S. Hanna, Chicago; A. Anderson, St. Louis, Mo.

United States Rubber Co., New York.—Hard rubber jars for car lighting batteries in various sizes with standard cover groove, soft seal groove and the deep-type with extra mud space; liners, separators and covers for battery jars; insulated wire and cable. Represented by George Gardner, New York; L. S. Hungerford, Jr., G. M. Haynes, J. F. McDonell, J. Luever, Chicago.

V. V. Fittings Co., Philadelphia, Pa.—"Reversible" conduit fittings; "Interchangeable" conduit fittings; vapor proof fittings; safety switches; heavy duty safety receptacles. Represented by A. K. Johnson, E. E. Rines, L. Fair, D. H. Fisher, Chicago; E. P. Burns, H. E. Hyde, Philadelphia, Pa.; Phil Schaum, Pittsburgh, Pa.; F. Tresselt, New York; W. A. Wilson, Kokomo, Ind.

Western Electric Co., New York.—Floodlights; Tork clocks; high voltage line switches; fuse blocks and fuses; "No. 99" lighting unit; electric drills and hammers; "Sunbeam" "Mazda" lamps; Habirshaw wire and cable. Represented by Geo. Hull Porter, H. C. Gump, H. C. Olmstead, T. J. Rider, Jr., J. O'Connor, C. V. Root, J. A. Brueck, E. C. Howard, J. A. Saville, Otis B. Duncan, Chicago; William Lancaster, Richmond, Va.; S. H. Christian, N. Y.

Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. —A new type of seal sleeve "Type C. S." squirrel cage

induction motor; parts of "Type C. S." motor; 440 and 2,200-volt air gap lighting arrestors; various types of Westinghouse "Mazda" lamps; 500-watt locomotive headlighter unit; Westinghouse heavy duty industrial safety switches; Full Safety Motor starters; "Type A. F." remote control starters for squirrel cage induction motors. Represented by W. W. Reddie, F. M. Hunter, A. M. Candy, H. H. Sener, J. W. Marshall, J. S. Gilmore, Charles Kerr, East Pittsburgh, Pa.; G. T. Keech, R. N. Kilner, C. W. Regester, W. R. Jacobs, L. A. Spangler, J. F. Hallowell, Chicago; H. M. MacMurchy, South Philadelphia, Pa.; R. H. Cook, Mansfield, Ohio.

Weston Electrical Instrument, Newark, N. J.—Indicating voltmeters; wattmeters; ammeters; a phase indicating meter; an electric tachometer. Represented by Paul A. Westburg, Leon C. Herrmann, Alvin Thielke, James F. Inmann, Chicago.

Willard Storage Battery Company, Cleveland, Ohio.—A train lighting battery group with rubber insulation between plates, removed from tank to show construction; a new type of single cell car lighting unit; a new type of 24 ampere-hour cell in glass jar for telephone, telegraph and radio service; radio A and B batteries; an electrolytic rectifier; two train control batteries. Represented by C. T. Klug, Louis Sears, Cleveland, Ohio; C. E. Murray, Chicago; M. J. Brennan, Detroit, Mich.

Daniel Woodhead Company, Chicago.—Diehl fans, Wheeler reflectors; Ackerman tape; Candee tape; "Adapti" boxes and conduit fittings; lighting glassware. This company also represented the Reading Chain & Block Corp. Represented by Daniel Woodhead, Stuart Standish, R. B. McFeely, Chicago; Arthur Gerald, Boston, Mass.; J. C. Boyton, Cleveland, Ohio.

Elementary Theory of Alternating Currents

A Series of Practical Articles Explaining a Difficult Subject in a Simple Manner

By K. C. Graham

Part VI. Generators

ALTERNATING current generators, called alternators, are similar in many respects to the direct current generator. They both contain an armature winding and a field winding, but the great difference between them is that the direct current machine has a

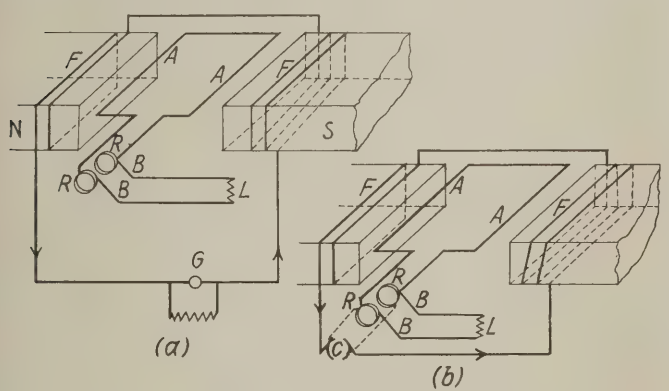


Fig. 47

commutator from which the current is collected, while the alternator is supplied with a set of collector rings for the same purpose. Brushes are used in both cases to connect the commutator or rings to the external circuit although the type of brush used for the direct current machine is different from that used in the alternator, a high resistance brush being used for the d.c. machine and a low resistance brush for the a.c.

The field coils are usually excited in the same manner as are those of the d.c. machine, by means of a separate d.c. generator called an exciter.

Fig. 47 (a) shows an elementary form of alternator consisting of armature *A*, field coils *F*, connected to collector rings *R*, from which current is transmitted to the load *L*, by means of brushes *B* and the necessary connecting wires. It will be noted that the field coils are excited by the separate generator *G*.

It might be asked why the field current could not be supplied from the armature of the machine, but it is impractical to use alternating current for field excitation because of many difficulties that we shall become familiar with as we go along. One of these is that the inductance of the large coils necessary to supply sufficient excitation is very high and another is that the frequency of the current supplied by such a machine would be unstable. These difficulties could be overcome by means of a small commutator mounted on the shaft of the alternator, so that the current might be rectified before being supplied to the fields. This method was used in some of the older alternators, as in 47 (b), where the auxiliary commutator is shown at *C*, but was abandoned because the expense involved in including this feature in the machine itself was greater, considering the relatively poor results ob-

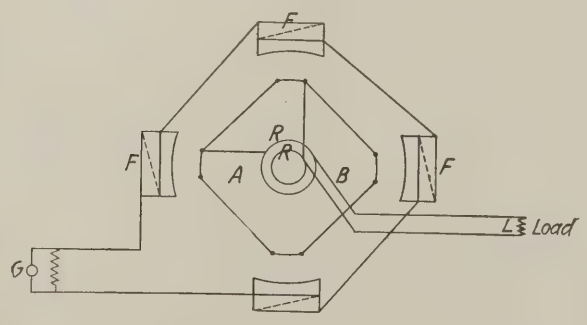


Fig. 48

tained, than that of having an external exciter. The exciter may be belted to the alternator shaft or direct-connected to a small engine. One exciter may be used to supply current to the field coils of one or several alternators, depending on its capacity. It might be well to repeat, at this point, that the frequencies of the currents in common use are 25 and 60 cycles, the 25 cycle current being used, largely, for power supply to large a.c. rail-

way systems, while the 60 cycle current is used for lighting. The reason that the 25 cycle current is used for power supply is that the inductive loss in the transmission line is less; inductance being equal to $2\pi fL$ so that at 25 cycles the loss is less than at 60. There are other more or less important reasons, but they need not be detailed at this time. The 25 cycle current is not adapted to use for lighting because the eye is able to detect the flicker of the 25 cycle current as it passes through the zero point of the cycle, whereas it is not possible to detect it with the 60 cycle current. Other frequencies have been used from time to time, but it is safe to say that the time will come when these two or, perhaps, the 60 cycle current alone will be universally used.

There are three types of alternators in use at the present time; the revolving armature, revolving field and inductor types. Fig. 48 shows the revolving armature type, and it will be seen that this alternator is practically the same as the direct current machine with the exception of the collector rings previously mentioned. The field coils are so connected that the poles alternate in polarity; north, south, north and south just as in the d.c. machine. The armature revolves between the poles and the current collected from the winding is passed to the load by the collector rings and the brushes. The field coils are excited by exciter *G*.

The revolving field type of alternator is illustrated in Fig. 49, where it will be noted that the field magnets are mounted on the revolving part of the machine while the armature winding is stationary. In either case the effect is the same because it matters not which part moves just so the field flux is made to cut across the armature inductors, motion being purely a relative matter.

The inductor type of alternator will be made clear by means of Fig. 50 (a). It is the same as Fig. 49, with the exception that a variable resistor *K* has been inserted in the field circuit, and the field magnets are to be considered as stationary; the armature and the field then being both stationary. Let the current through the field coils be a certain very small amount, and suppose that the resistor *K* were suddenly short-circuited, thus causing the field current to increase. This would cause a large increase in the flux threading the armature inductors and a

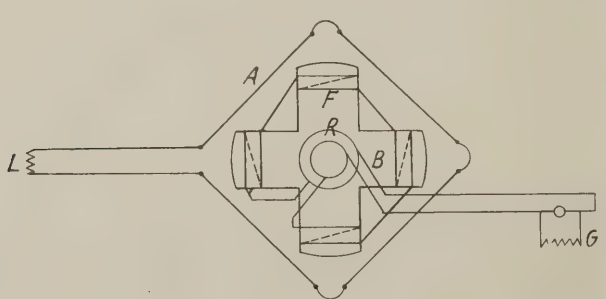


Fig. 49

voltage would be generated in them due to this change of flux. Then as the current and the flux attained a steady value the voltage in the armature would fall to zero, but if the resistance were again inserted the flux would decrease and a current would be induced in the armature inductors so long as the flux was changing. Thus we see that it would be possible to generate a current in the armature inductors without any relative motion on the part of either the armature or the field. This same result is brought about in the inductor alternator but in a somewhat different manner. Fig. 50 (b) shows two sets of horseshoe magnets with windings on each of the poles. One set of these, *F*, is excited by generator *G*, while the other is connected to load *L*. A ring *I* of iron or other magnetic material is located between the two sets of poles. Suppose the coils *F* to be excited by the generator and the magnetic material, *I*, to be suddenly removed; then the flux passing through the circuit will change from a high to a low value due to the increase of the reluctance or magnetic resistance of the circuit which results from the substitution of an air connecting path for the low resistant iron path. This will result in a voltage being induced in the coils on magnet *A*, and a current

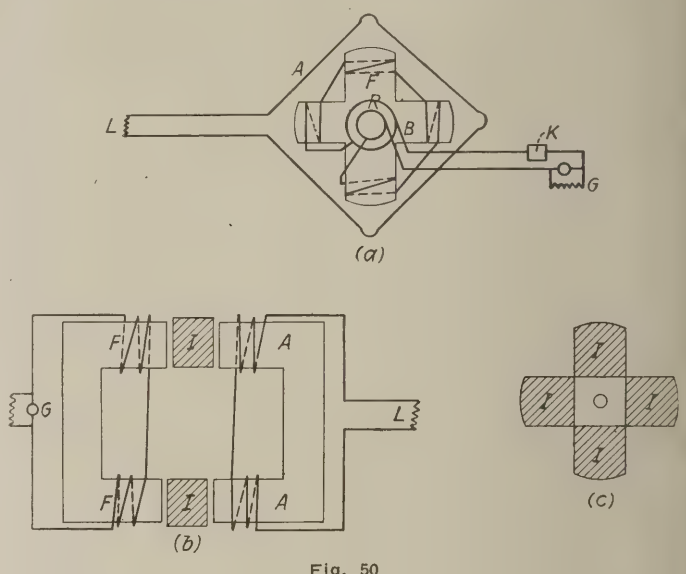


Fig. 50

will flow through the load *L*. Again, when the ring is reinserted the flux will change from a low to a high value and a current will flow through the load. This result could be easily brought about by mounting as many magnetic pieces as there are poles on a revolving member as in Fig. 50 (c), so that as it revolves an air path and a conducting path are presented to each of the poles in regular succession. This illustrates the principle upon which the operation of the inductor alternator is based.

The revolving armature type was the original type of generator, and although some of them are still in use, they have been practically superseded by the revolving field type. The advantages of the revolving field alternators are that the collector rings and brushes need be very small because of the low value of current necessary to supply the field excitation; the revolving member contains a simple winding which is not subject to any inherent troubles; it is much easier to provide for a positive form of insulation for the high voltage armature conductors if they are stationary rather than mobile, and the weight of the revolving member is much less than in the revolving armature type. As to the inductor type, it was never very generally used because of high cost and its great weight as compared to the other types, so that there are comparatively few of them in use at the present time.

The field windings, as previously mentioned, are constructed and connected in exactly the same manner as are those of the d.c. machines but the armature windings are not. The detailed study of windings will be taken up in connection with that of the induction motor, but it would be well to study the main points as applied to single, two and three phase alternators.

Fig. 51 illustrates the method of connecting the wind-

ings on the armatures of two and four pole, single, two and three phase machines. Fig. 51 (a) shows the method of connecting the coils of a two pole single phase armature. It will be noted that they are grouped and connected in exactly the same way as the field coils of a direct current or alternating current machine. There are only two coils shown in the figure, but if the winding had consisted of four coils they would have been grouped together in two sections of two coils each, connected in series, and these two groups would then have been connected as are the single coils in the figure. This is true of all alternating current windings with the exception of the little used wave winding which we shall take up later on. Fig. 51(b) illustrates a four pole, single-phase armature winding and hardly needs further explanation. Fig. 51 (c) shows a two pole two-phase winding. It will be noted that the two windings are 90 electrical degrees apart, the distance between the centers of two poles of like polarity being taken as 360 electrical degrees because the current through a conductor passes through a complete cycle while passing from the center of a north pole to the center of the next north pole or between the center of a south pole and that of the next south pole; a cycle representing 360 electrical degrees.

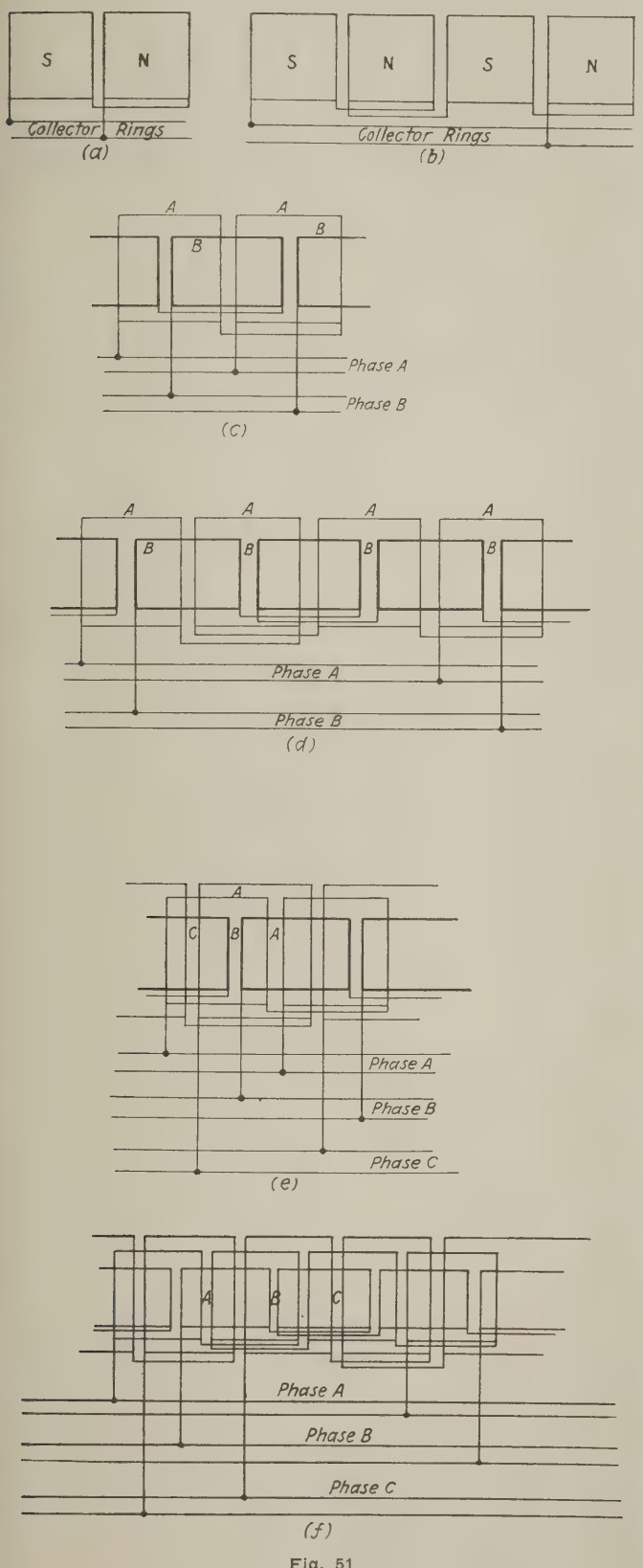


Fig. 51

Fig. 51 (d) shows a 4 pole two-phase winding; Fig. 51 (e), a 2 pole three-phase winding and Fig. 51 (f), a 4 pole three-phase winding. It will be noted that the windings of the three-phase machine are spaced 120 electrical degrees apart. The terminals of all the windings in the above figures are brought out to separate collector rings, but the windings of the two-phase machine might be brought out to three rings and that of the three-phase might also be brought out to three rings, as previously mentioned in connection with the study of elementary current generation.

The shape of the curve representing the voltage generated in an alternator having a uniform distribution of flux in the air-gap (between the field poles and the armature laminations) is somewhat as shown in Fig. 52. This is the familiar sine wave of voltage (or current), the value of the voltage varying from zero to a maximum. The question now arises, "How shall this voltage be designated; by its maximum value, its average value or some other value?" If we are to preserve the same standards for alternating and direct currents it is evident that we must find some way of expressing the voltage so that it will be equivalent for both alternating and direct. The simplest method of comparison is that of relative heating. A direct current of a given value, say one volt, is impressed upon a resistor for a given time and the rise in temperature of the resistor is accurately measured. The voltage of an alternating current generator is then varied in the neighborhood of one volt until its effect on the resistor is exactly the same as that of the one volt direct current. This voltage is then accurately determined and found to be 1.414 volts at the maximum point of the wave. The equivalent value of the whole wave is, then, only one volt whereas its maximum value is 1.414 volt so that we say the effective value of a sine wave of alternating voltage or current is .707 times (.707 times 1.414 equals one) its maximum value. The average value is seen to be somewhat less than the effective value, or .636 times the maximum value, Fig. 52. An alternating current ammeter or voltmeter registers effective amperes or volts as the case may be so that if the reading of the voltmeter is one volt we know that the maximum value is 1.414 volts and the average value is .636 times this or .9 volt. Whenever we speak of volts or amperes, then, we refer to effective volts or amperes unless it be specifically mentioned that one of the other values is referred to. Now, a word as to the value of the voltage generated in the armature of an alternator.

It will be remembered that in the study of direct currents we found that a voltage of one was induced in an inductor if it cut lines of magnetic flux at the rate of a hundred million lines per second so that all that was

necessary to determine the voltage generated was to multiply the number of revolutions per second by the flux per pole, the number of poles and the number of inductors in series; the total being divided by one hundred million and the result being volts. This is complicated somewhat, in regard to the alternating current machine, due to the difference between the maximum and effective voltage values referred to above. In order to make this clear let us refer to Fig. 53.

Loop *A*, Fig. 53 revolves between poles *N* and *S* at the rate of *R* revolutions per second. Since this is a two pole machine this is equal to the frequency which is denoted by *f*. The number of lines cut in one second will be *f* times flux per pole times two (two inductors in series in the loop) times two (the flux of each pole is cut during the revolution, this being equivalent to cutting that of the one

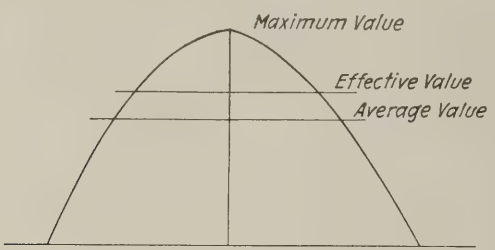


Fig. 52

pole twice per revolution). This is equivalent to saying that the number of lines cut is equal to 4f times flux per pole. If the loop had consisted of two turns this result would be multiplied by two; if three turns, by three, etc., so that if we denote the number of turns by *n* we may change our formula to read—lines cut per second equal 4fn times flux per pole. The voltage, which is equal to this value of lines divided by one-hundred million will represent the average of the generated voltage because we really took an average value of the rate of cutting the flux when we incorporate in our formula a certain value of flux cut per second without regard to its variation from instant to instant. The maximum value is equal to this average value, $4fn$, divided by .636 which gives as the maximum value of the voltage—(6.2832 fn times flux)

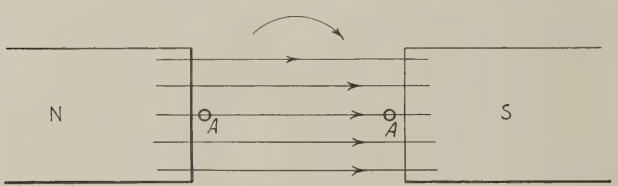


Fig. 53

divided by 100,000,000. The effective value is .707 times this. Carrying through our multiplication gives us (4.44fn × flux) as the effective value of the voltage.

$$\frac{}{10^8}$$

This formula holds true regardless of the number of poles and the speed of rotation; the frequency takes both of these factors into consideration. Thus the voltage generated in a two pole 60 cycle alternator revolving at the rate or 60 revolutions per second will be the same as that generated in a four pole machine rotating 30 times in a second for the same flux per field pole. It will be well to remember the formula obtained as above because we shall have occasion to refer to it again in connection with induction motors.

The operation of alternators is affected by the nature of the loads to which they may be connected. Fig. 54 (a) shows one of the four coils of a four pole armature winding as it passes the centers of two of the field poles. If the alternator is connected to a load the power factor of which is 100 per cent the current will vary in phase with the voltage and the flux from the coil will react on the field poles, decreasing the magnetism at one side of the pole and increasing it at the other the net result being

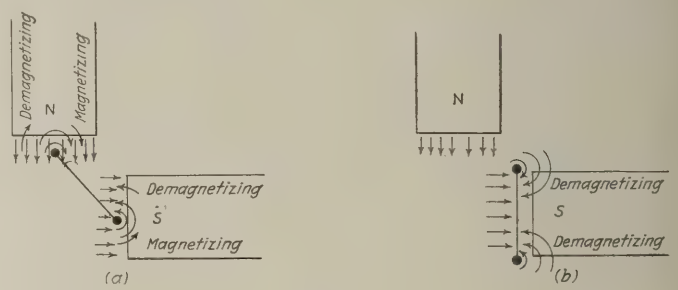


Fig. 54

that the only decrease in total magnetization is that due to saturation in the side at which the flux is increased. This effect of the flux resulting from current in the armature inductors is known as armature reaction and the particular phase which is illustrated in Fig. 54 (a), is known as cross magnetization. Its effect on the total magnetization is usually rather small.

Fig. 54 (b) illustrates the effect on the operation of the alternator occasioned by an inductive load the power factor of which is practically zero so that the current lags 90 degrees behind the voltage. Here it is seen that the coil is in such a position that its flux opposes that of the poles when the current through it is at the maximum value. The coil flux is thus demagnetizing and this effect is known as demagnetizing armature reaction. The average condition of load has a power factor between these two extremes so that the effect of armature reaction is partly cross-magnetizing and partly demagnetizing. Either or both of these effects tend to decrease the field strength, that of the demagnetizing component being especially active in this regard so that it is necessary to increase the field strength, when the load is applied, to maintain constant voltage. Then if the load be suddenly removed the voltage will rise an amount depending on the degree that the total field strength is affected by armature reaction and the resistance of the armature winding. The percent of full-load voltage that the voltage increases as the load is decreased from full-load to no-load is known as the regulation of the machine. This feature is useful in determining the type of machine best suited to a given type of load.

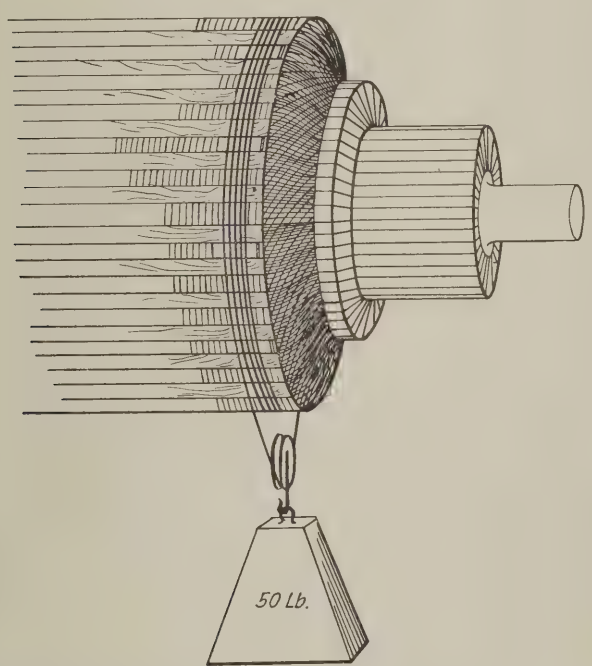
Stop-Look-Listen Clubs

Missouri Pacific employees a little over a month ago started "Stop-Look-Listen clubs" and have organized 106 clubs with a total membership of nearly 25,000 automobile owners and drivers. The Southern Kansas division club has succeeded in securing the support of nearly all the big oil companies which have required their drivers to sign the pledge and display the sign, "This Car Stops for All Railroad Crossings."

Banding Armatures By the Weight Method

The most common method used to put banding wire on an armature after it has been repaired or rewound, consists of fastening one end of the wire to the armature and winding the wire on by rotating the armature, the proper tension being obtained by pulling the wire between two fibre blocks bolted together. The disadvantage of this method is that it is difficult to turn the bolts down to a certain tightness and as the wire wears a groove between the blocks the tension on the wire changes.

When the weight method is used, each turn of wire in a band will have the same tension as each of the others



Showing the Application of a Weight in Banding Armatures

and there will be little if any differnce in the tension of wires in different bands. The armature is first placed in a horizontal position so that it is free to turn; usually in a lathe. Enough wire for one band is then wound on in place loosely by hand. One end of the wire is slipped through a pulley and the two ends of the wire are spliced together. Banding clips are then slipped under the wire at proper intervals and a weight is hung on the pulley as shown in the illustration. A 50-lb. weight is shown but this should be varied somewhat depending upon the size of the banding wire used. To obtain the desired tension, the armature is rotated so that the pulley with its suspended weight travels along the banding wire from one end to the other. This causes each turn of the banding wire to support the weight as it moves along and in this way its slack is pulled out and held automatically as it is pulled out. The armature is rotated until the pulley has traveled from one end of the banding wire to the other and then reversed until the pulley returns to the place it was put on. Finally the clips are bent over in the usual manner, the wires and the clips filled with solder, and the two ends of the wire which supported the pulley and weight are cut off.

Small Solder Iron for Light Work

There often arises the necessity for a small inexpensive soldering iron for light work. Such an iron can be used in places where larger irons are too clumsy.

The copper can be obtained at any trolley barn or at any power station where large gage wire is used. A hole,

Small Soldering Iron for Light Work

just the size of a bond wire, such as used by the signal department in bonding track, is drilled in the copper at one end to permit a good tight fit. The bond wire is placed through this copper and by holding in a vise the bond wire is twisted to the shape shown in the drawing.

If it is necessary to point the iron at an angle, as in doing close work in restricted space, the bond wire shank can be bent very easily.

Handy Polarity Indicator

By J. C. Moore

A voltmeter may be damaged so as to need repairs if it is placed in a circuit (direct current) with the leads reversed, and to make certain that this does not happen to my voltmeter, I carry in the same case with the voltmeter a small polarity indicator which is used on a machine before the voltmeter. This was constructed by placing in each end of a half-inch glass tube two inches long a piece of number 14 rubber-covered wire from which the insulation has been removed for a quarter of an inch from the end, bushed to fit the tube by wrapping it with rubber tape. The space between was filled with water,

and can be refilled as often as may be needed. In use the ends of the two wires are only an eighth of an inch apart, and the negative wire will bubble violently when the indicator is placed across the terminals of a 32 volt generator.

He Tried to Make a Touch

A goof came in the other night and said, "I like the stuff you write, for its wit and logic shine: sometimes you pound us on the bean, with hidden meanings in between, each rough and uncouth line" . . . "While pricking through a tender skin, *you* can sit immune and grin—like an ancient Chinese Joss—yet everyone who stops to read, picks inspiration from each creed, for you put your point across" . . . "If I could write such lines that please, and do it with such graceful ease, I'd dodge this life obscure; so hitch your wagon to a star, and show the world just what you are, in the field of literature" . . . "—— and when you reach some dizzy height, you might a few of us invite (say six or eight or ten) where we can sit in perfect bliss, and smoke and talk and reminisce—about *I knew him when* ——". . . . "Some day we'll find your bust and name, nestling in the Hall of Fame, with Riley, Guest and Ade: all that you have got to do, is slip the brakes that's holding you, and amble up the grade" . . .

'Twas then he sidled up real near, this goof so full of bull and cheer, and softly slipped his clutch: he slapped me on the boney back, and using smooth and oily tact, *he tried to make a touch* . . . It made me sort o' sore and hot, to see him *waste it* on a Scot—for "Jack" he couldn't get—for one brief moment I just smiled, then getting madder I turned wild, and *I think he's running yet.*

There Are Others

Don't imagine, my boy, if you throw up your job
That the firm which employs you will fail;
That the whole office force in their anguish will sob,
And the senior partner turn pale.
You are highly efficient and active and bright,
So you say; I'm unwilling to doubt you.
But the chance of all this is incredibly slight—
There are plenty of others without you.

Don't get mad with the girl and make her feel bad;
Fail to go for your usual call.
It's the truth, though I know it sounds awfully sad,
That she may never miss you at all.
It's a mighty poor policy staying away,
Though I grant that at times she may flout you;
But I know that I'm in a position to say
There are plenty of others without you.

Don't get soured on the world and do anything rash,
Not to speak of the good of your soul;
If you jump in the lake you may make a small splash
But you'll never leave much of a hole.
Don't expect folks to make such a terrible fuss,
When they think very little about you;
And, to use common language, aren't caring a cuss—
There are plenty of others without you.

Answers to Questions

1. *Is there any limit to the thickness of metal that can be welded by the electric arc welding process?*
2. *What is Lenz's law of induced currents?*

Limits of Arc Welding

1. As time goes on and we learn more and more about electric arc welding it would seem that there is almost no job that can not be successfully accomplished with this process. Concerning the thickness of metal it may be said that very heavy sections are being welded with perfect success with the electric arc. Thin material apparently can be welded satisfactorily if the proper methods are used, and heavy sections can be equally well handled when preparations are correctly made for this work. The welding of locomotive frames is quite a common practice, and even sections much heavier are needed.

It is sometimes desirable to reinforce heavy sections with additional strips of material. Such strips are usually put on the outside of the welded section and covered with a pad of welded material. The success or failure of a large weld is for the most part a matter of the efficiency of the welding operator. Of course, care must be taken to prevent warpage in the parent metal.

With regard to thin metal sections, it was brought out at the recent convention of Association of Railway Electrical Engineers that car roofs can be very sucessfully handled, and the gage of this metal is from 16 to 20. In general it may be said that there is almost no limit to what may be accomplished with the electric arc process if the work is properly prepared and skillfully performed.

Lenz's Law of Induced Currents

2. The actual statement of Lenz's law of induced currents is as follows: In all cases of electro magnetic induction the direction of the induced current is such as to tend to stop the motion producing it. For example, let us assume two coils of wire side by side, one of the coils being connected to a volt meter and the other to a source of current. When current is sent through the latter coil, the coil will take upon itself the qualities of electro-magnet, one face of the coil becoming a north pole and the other a south pole. When the current is connected to the first coil an induced current will flow in the second coil connected to the voltage meter. The sides of the two coils which face each other will be of the same polarity. In other words, the coils would tend to repel each other. Looking at it in another way, the induced current in the second coil sets up a magnetic field which opposes the field set up in the first coil, due to current passing through it. Again, when the current is cut off from the first coil and the magnetic field collapses, the field set up in the second coil will reverse and tend to maintain the field of the first coil as it originally was.

Questions for November

1. *Do you believe that radio antennae should be rightfully considered as a lightning menace?—H. F.*
2. *Is the head-end system of car lighting coming into style again? I have heard considerable about this from one place or another recently.—E. W.*

NEW DEVICES

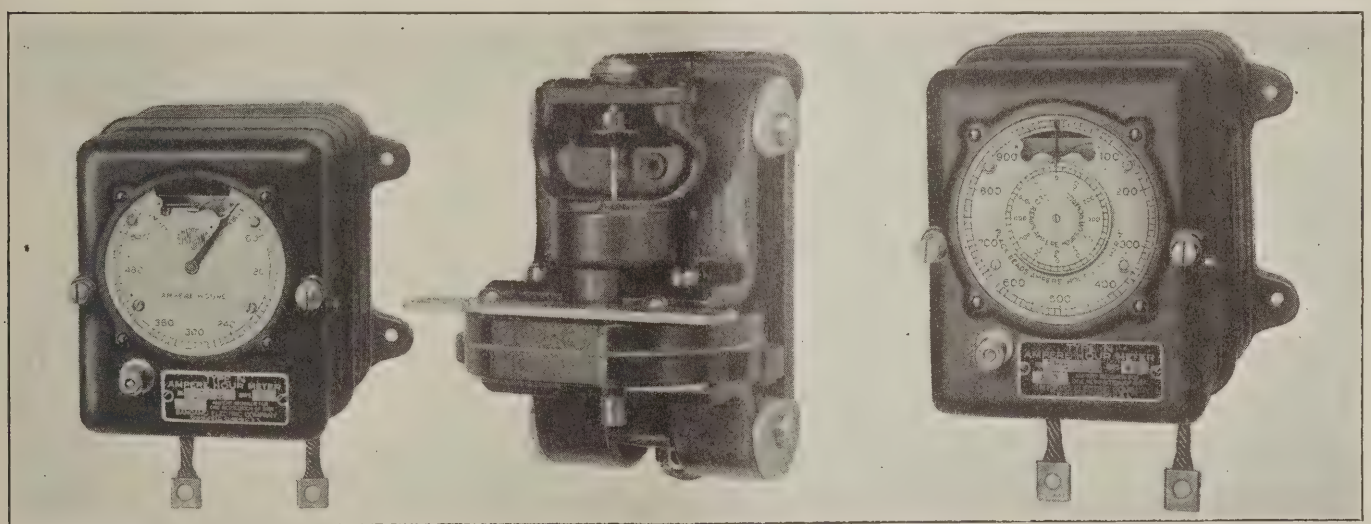
Sangamo Types NCR and NCI Amperehour Meters

Two new amperehour meters of an improved type which have been developed by the Sangamo Electric Company, Springfield, Ill., should be of interest to train lighting engineers. The new meter, known as the type N, is radically different from former Sangamo meters used in this field, being somewhat smaller, simpler and decidedly more substantial and strong. It has a higher torque than previous meters, resulting in greater sustained accuracy and making unnecessary the use of a thermo-couple for light-load compensation.

The construction is such that only two large magnets are employed. These provide both the driving and damping forces which act upon a single disk in the mercury chamber. There are no exposed moving parts except the main shaft and a counter weight. One simple adjusting device is all that is required to regulate the meter speed. A new lower-bearing construction together with a special process of treating the armature chamber, the manufacturer states, make it unnecessary to clean the mercury except at infrequent intervals. The type N meter for train-lighting service is made in two forms to meet the various requirements of axle-generator, head-end and straight storage systems. These two forms are known as types NCI and NCR.

The type NCI meter introduces an entirely new feature, which consists of a register which indicates the amperehour discharge from the battery and also the excess or waste charge in amperehours. It has a regular circular dial and black hand which indicates the amperehour discharge from the battery. The meter is arranged to run slower on charge than on discharge in order to give the battery the requisite overcharge. The position of the black hand is therefore always an indication of the condition of the battery at the moment a reading is taken. A small red circular dial is mounted on the center staff over the main dial, and is read by an overhanging pointer on the black hand. This dial indicates the amperehour charge put into the battery beyond the true full point and will show immediately whether or not a battery is receiving a damaging overcharge. The advantages claimed for the type NCI meter on axle-generator and head-end systems are as follows:

1. Longer battery life because meter indicates damaging overcharge or a condition of continued undercharge. 2. Battery will have to be opened up less frequently to take hydrometer readings. 3. Battery will require flushing less frequently. 4. Condition of the battery may be



The Type NCI Indicating Amperehour Meter Is Shown at the Right and the Type NCR Regulating Amperehour Meter at the Left. The Motor Element Shown in the Center Is Used in Both Instruments

determined by a glance at the dial. 5. Proper adjustment of the regulator may be readily determined since meter indicates both overcharge and undercharge. 6. On head-end equipment, meters enable all batteries to be maintained at full charge without danger of overcharging battery nearest the generator. 7. The installation of a meter does not complicate either generator or head-end equipment, it being simply an indicating device.

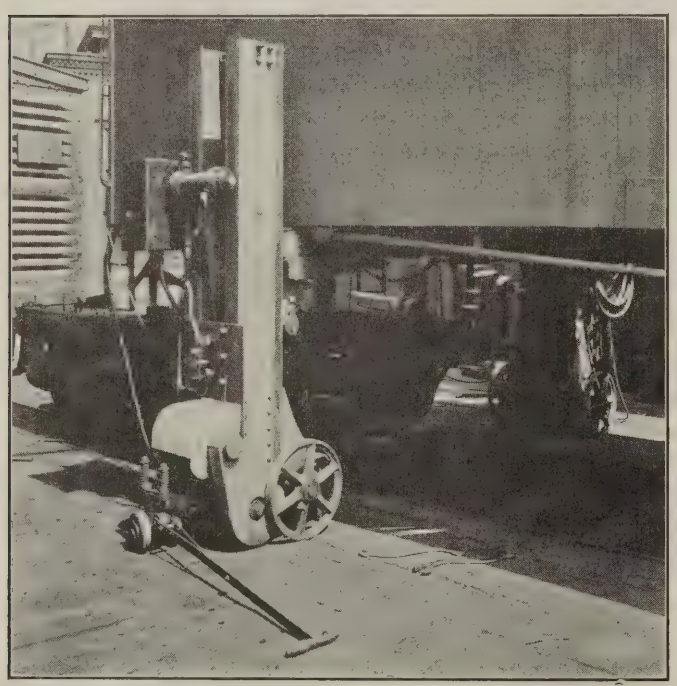
The type NCR meter for regulating service has a single dial and pointer which indicates the condition of the battery at the moment a reading is taken, the meter being built to run more slowly on charge than on discharge in order to give the battery the requisite overcharge. On charge a contact is closed when the meter reaches the full point. This contact functions, through a relay, to introduce resistance into the generator field circuit, thus reducing the generator voltage to the battery floating voltage. This method provides positive means of preventing overcharge. The meter is mounted on a sub-base which makes it interchangeable with Sangamo type D-5 ampere-hour meters now in service.

The type NCR meter is adaptable to straight storage systems and to axle-generator and head-end systems in cases where automatic regulation of the generator output is desired.

Car Hoist Which Combines Speed with Safety

A unique portable car hoist has recently been placed on the market by The Whiting Corporation, Harvey, Ill. It embodies the same basic principles as the Whiting locomotive and car hoists which have become well established in recent years.

The Whiting portable hoist is a motor-driven screw



A Motor Driven Screw Jack Whiting Car Hoist

jack mounted in a substantial frame with three bearing surfaces, spaced to give much greater stability than in ordinary jacks. A toggle arrangement raises the jack off these bearing surfaces and allows it to be pulled from place to place on wheels like a small truck. One, two, or four hoists can be operated as a unit, the control being centralized in one push button station.

The portable unit makes unnecessary a special foundation or pit, and its use is extended to any point in the shop or yard where there is a level floor capable of supporting the load. These hoists are as easily portable as other heavy duty jacks and their greater stability adds to their safety. Power is required to lower the load so that a car can be supported on the hoists without blocking and left over the noon hour or over night without danger.

The portable hoist can be used under any type of car and for any operation. When removing the trucks, four are used, two at each end of the car, permitting the trucks to be grouped and handled together. When removing one, two or three pairs of wheels, or renewing springs, two hoists are used and the truck is supported by suitable clamps from the under frame of the car during the lifting operation. This universal application makes possible the elimination of many sizes and styles of jacks ordinarily used. In one recent installation, 12 such jacks were replaced by one set of hoists.

Universal Outlet Receptacle

The Central Electric Company has recently brought out a line of "Ralco" receptacles with what is termed a universal housing. The housing is drilled and tapped at the top, on either side and on the bottom for conduit. The top and side openings are closed with removable plugs permitting the use of the outlet on practically any conduit

Style "X" Housing for "Ralco" Receptacles.

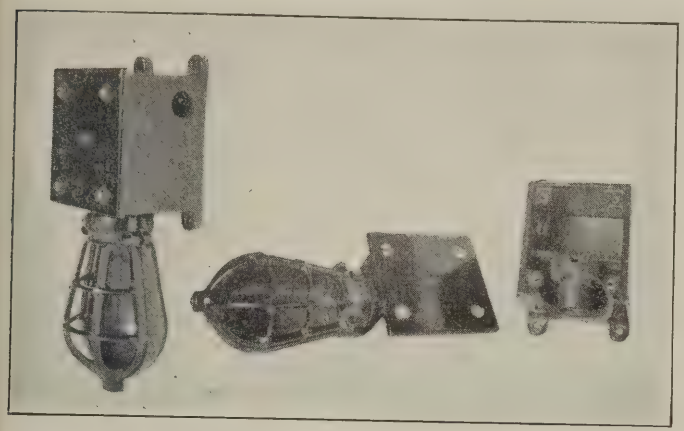
layout without special drilling. The outlet is furnished in sizes as follows: 3 pole, 30 amp., 600-volt; 2 pole, 30 amp., 250-volt; 3 pole, 30 amp., 250-volt; 2 pole, 30 amp., 600-volt; 4 pole, 30 amp., 250-volt; 4 pole, 30 amp., 600-volt. Standard Ralco receptacle units and plugs are used, nothing being special except the housings.

A Pit Light

A lighting fixture for engine pits, coal chutes, etc., which is moisture proof without being vapor proof, was devised recently by the Oliver Electric & Manufacturing Co., St. Louis, Mo. The fixture is of rugged construction, the box being made of cast iron and the guard of special pre-heated cast aluminum alloy.

The front of the box can be removed as shown in the illustration and the lamp guard can be opened by releasing two cap screws when it is necessary to renew or clean the lamp.

These fixtures are made for ½ in., ¾ in. and 1 in.

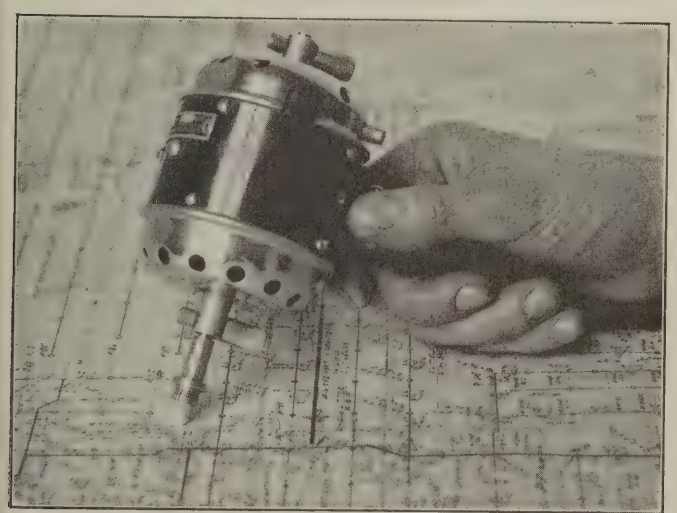


The Pit Light Complete and With Cover of Box Removed to Show Marine Type Socket

conduit with the conduit opening either in the back or on each side. It is known as the type of P. L. Pitlight, and is made in two sizes. The smaller size will take a 75-watt lamp, while a 200-watt lamp can be used in the larger size.

An Electric Eraser

Various types of motor driven erasers for drafting room practice have been tried out in the last few years, but they all have had some objectionable features, such as excessive wear of delicate parts due to eccentric loading of motor; breaking of the flexible cable; excessive noise from the motor, and the tendency of the disk eraser to cut



An Electric Eraser Which Will Clean Tracing Cloth Quickly and Not Tear It

through the drawing surface. Keeping these points in mind, C. F. Seymoure, of Swarthworth, Pa., has designed an electric eraser that apparently has overcome these objectionable features.

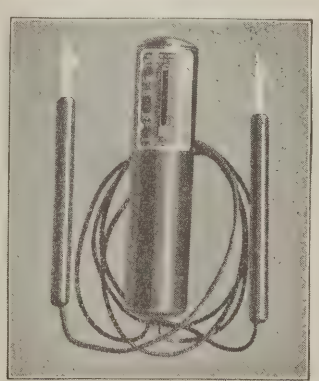
The machine is driven by a variable speed motor, which derives its power through an electric light socket attachment. The shaft of the motor to which the eraser holder is attached will run at three different speeds which are controlled through a three position lever. The eraser holder is a hollowed, longitudinally segmented, cone frustum with the inside knurled and the segments brought in close contact with the eraser by a ring that slides over the lateral faces of the segments.

The formula for the erasers was adopted after much experimenting. It was found that if an abrasive was used the eraser would go through the drawing surface, and if no abrasive was used "glazing" resulted and the drawing was smeared. The abrasive used is powdered pumice stone, which gives satisfactory results.

The machine weighs less than two pounds and is simple to operate. The starting device and the variable speeds are obtained by a small movement with the thumb of the hand holding the instrument. The motor speeds are controlled by "stops" in the field wiring. This eliminates a rheostat and as a result no heat is generated by changing the speed. The shaft of the motor is held at an angle of 45 deg. with the plane of the table. The gyroscopic action of the motor armature tends to hold the machine at a constant angle. The weight of the motor is just sufficient to give the proper pressure on the drawing surface to eliminate a glazing of the eraser by the ink. It is only necessary to guide the machine with the fingers and it can be used any length of time in this position.

A Voltage Tester

A small pocket size device for testing voltage, which does not require the use of lamps is being marketed by the Square D Company, Detroit, Michigan. The device which is known as the Wiggington Voltage Tester is enclosed in a fibre shell 5½-in. long and 1¼-in. in diameter; the tester complete weighing about 7 ounces. The operating mechanism in the tester consists of a magnet coil which operates a plunger against the tension of a spiral spring. A pointer which is attached to the plunger travels in a slot between a direct current scale on the left and an alternating current scale on the right. The maximum reading on the alternating current scale is 440 and the maximum reading on the direct current scale is 550. If the operator is in doubt as to what kind of current he is testing, the tester will determine this for him, as when it is used on alternating currents, the vibration or hum caused by the current can be felt. The tester is furnished with long lead wires terminating in testing points or hooks fitted into insulating fibre handles. The hooks make it possible to place the lead wires on the circuit, leaving the electrician's hands free. The sharp points make it possible to pierce the insulation of wires when necessary without materially damaging the insulation.



The Wigginton Voltage Tester

General News Section

The joint passenger station of the Missouri Pacific and the St. Louis-San Francisco at Hoxie, Ark., was damaged by fire on October 9, with loss estimated at $25,000.

The Great Northern has authorized the installation of automatic train control between Minot, N. Dak., and Williston and the equipping of passenger locomotives for automatic train control.

The Interstate Commerce Commission has granted the petitions of the Chicago, St. Paul, Minneapolis & Omaha and the Western Maryland for relief from its train control orders of June 13, 1922, and January 14, 1924.

The Interstate Commerce Commission has issued a modification of its automatic train control order to permit the Chicago, Burlington & Quincy to make its installation between Creston and Pacific Junction, Ia., instead of bebetween the points specified in the order.

The Interstate Commerce Commission, Division I, has set aside its order of September 10 denying the petition of the Chicago, St. Paul, Minneapolis & Omaha to be relieved from the commission's two orders requiring the installation of automatic train control.

The Gibb Instrument Company of Bay City, Michigan, manufacturers of electric welding and electric heating equipment, announce the appointment of H. V. Beronius to represent it in Iowa, Kansas, Nebraska, Oklahoma, and Northwestern Missouri. His headquarters will be at 33 Linwood Terrace, Kansas City, Mo.

An Explosion on a Canadian Pacific passenger train near Vancouver, B. C., on October 29 resulted in the death of five persons and the injury of 12. It is believed that the explosion was a result of a plot against Peter Veregin, a leader of the Doukhoubor colony in British Columbia, who was among those killed.

The Roller-Smith Company, 233 Broadway, New York, N. Y., announces the appointment of Charles R. Speaker, Evening Star Building, Washington, D. C., as its representative in the District of Columbia. Mr. Speaker will also handle the Roller-Smith Company's Government business in the States of Maryland, Virginia, North Carolina and South Carolina.

Near Clover, Pa., on the Cambria & Indiana Railroad on the morning of October 11, passenger train No. 12 was stopped by robbers, who carried off in their automobile a safe containing $33,000, money being sent to the Colver mines of the Ebensburg Coal Company; and James Garman, express messenger or guard, was killed. One other man was wounded. The robbers numbered five, and were not masked. Several bullets were fired among the passengers on the train.

The longest electrified railway in Europe at the present is a line of 296 miles in Sweden, where the total amount of line electrified aggregates about 500 miles with an addition of 284 miles of line now undergoing electrification. Austria while having practically no electrification at present has provided by law for the immediate electrification of lines totaling 1,143 miles. In Germany 360 miles of main line have been electrified. Electric traction has been applied to 890 miles of tramways and to 320 miles of secondary track in Italy.

Howell Motors to Establish Flat Price Schedule for Rewinding Motors

The "Rewinding of motors," "Timken roller bearings for motors" and "Types of motors" were considered at a recent sales convention held by the Howell Electric Motors Co., which was attended by most of the leading distributors in the Howell organization from all parts of the country. Announcement was made that the factory is now preparing for the use of the distributors a flat price list for rewinding motors. The use of Timken roller bearings which have seen service on some of the Howell motors for the last year and a half was discussed, and a decision made to put out at once a complete line of motors equipped with these bearings. The development of new modifications of the Red Band motors such as multispeed motors, vertical motors and frequency changers was described by C. F. Norton, general manager of the Howell Company.

Power Show to Feature Lectures

The Third National Exposition of Power and Mechanical Engineering will feature a series of lectures on recent developments in important phases of power-plant and mechanical engineering practice. The exposition will be held in the Grand Central Palace, New York, from December 1 through 6, 1924, and the lectures will be held in the assembly hall. The topics selected are: The Boiler Room, Steam Prime Movers, Oil and Gas Engines, Hydro-electric Power Plant Equipment, Materials Handling, Modern Machine Tool Developments, Mechanical Power Transmission, Mechanical Refrigeration, Heating and Ventilating. The exhibits, which will occupy 150,000 square feet on three floors of the Palace, will include a complete showing of all lines of power plant apparatus and accessories.

Flash Light Powder Causes Arc-Over

A flash-light powder near a high-voltage circuit recently caused a flash-over in an Indiana power plant, it was reported to the Ft. Wayne Works of the General Electric Company. This phenomena was checked by E. A. Wagner, managing engineer of the transformer department. A flash was set off beneath a circuit carrying 13,000 volts. Under ordinary conditions 90,000 volts

would have been necessary to cause an arc-over across the distance of approximately nine inches which separated the two wires. The flash powder, located four feet beneath the wires, caused a dead short which threw open the main breakers on the circuit. The dust and hot gases rising between the bare wires were apparently ionized, became conductive, and carried the arc.

Supervisory Control at Staten Island

In connection with the Baltimore & Ohio electrification at St. George, Staten Island, there will be a 3-unit semi-automatic substation, each unit of 1,000 kw. capacity; 2-unit, full automatic stations at South Beach, Dongan Hills and Eltingville, and a single unit substation, also full automatic, at Atlantic (near Tottenville). All converter units are of 1,000 kw. capacity. Power is supplied these stations by the Staten Island Edison Corporation, at 33,000 volts, 60-cycle, 3-phase, and is converted to 600 volts d-c. for use through the rails to the cars.

The dispatcher is located at St. George, and, through the medium of supervisory control and its continuous lamp indicator, is not only continually aware of the operating status of each substation, but can start or stop any machine, open or close any a-c. or d-c. feeder circuit. He also controls all signal power circuits. The signals operate on alternating current.

A feature intended to insure continuous operation, insofar as is possible, is the method of superimposing the supervisory control on the full automatic substations. It is so arranged that, should the supervisory equipment, or the dispatcher himself, fail to function properly, the substations, except St. George, become isolated, operating as full automatic substations, starting, stopping, etc., as the load conditions demand, entirely independent of the dispatcher.

Metropolitan-Vickers to Electrify Australian Line

According to a cable dispatch from London to the Journel of Commerce (New York), a contract for the electrification of the suburban lines of the New South Wales Government Railways in the Sydney district has been awarded to the British electrical firm of Metropolitan-Vickers, Ltd. The work calls for an expenditure of some £500,000.

Radio Telegraph on the N. C. & St. L.

The Nashville, Chattanooga & St. Louis has on the Huntsville division a wireless telegraph apparatus with which it does business regularly. The sending stations are at Tullahoma, Tenn., and Guntersville, Ala., and routine statistical reports, telegrams, etc., are transmitted between the Tennessee and Coosa Branch and Division headquarters at Tullahoma; and all other communications which were formerly relayed to and from that branch by commercial telephone from Huntsville. There is a gap between Hobbs Island and Guntersville where the road has no wires.

Experiments began with the wireless some four or five years ago at these places and due to some difficulties, such as the location of the station at Tullahoma, on account of high power used in transmitting set, it being almost impossible to insulate satisfactorily, the interference rendered electrical appliances of dentists, banks, including burglar alarms, also the time vault, which was at one time rendered inoperative, and other occupants of the building in which offices were located at that time, made it necessary to discontinue operation of station until further location was secured; and this, primarily, prompted the erection of the beautiful and modern office building, headquarters of the Huntsville Division, in which the station is now located; and permanent operation was established two years ago.

The huge aerials are suspended from high steel masts, which afford a very attractive appearance causing the station to be visited by hundreds of radio enthusiasts.

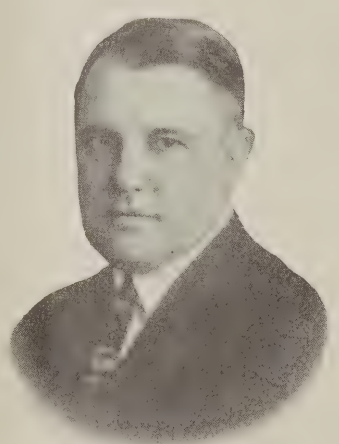
The receiving sets used are the popular Zenith and the transmitters are of the non-synchronous spark type, both manufactured by the Chicago Radio Laboratories, of Chicago.

The stations are operated on wave-length of 1,621 meters by Dispatchers G. S. Tally and S. B. Gribble at Station WJJ, Tullahoma, and E. W. Crabtree at Station WKH, Guntersville.

The economical feature of the wireless, will, no doubt, cause a great expansion of its use in railroad circles. Representatives from various eastern railroads have visited these stations and are making experiments.

Personals

George H. Scott was elected president of the Railway Electric Supply Manufacturers' Association on October 24th at their annual meeting in Chicago, Illinois.



Geo. H. Scott

Mr. Scott was born on June 6th, 1880, in Hancock, Missouri, where he received a public school education; later he had a three-year normal school training. During the early part of 1899 he entered the services of the St. Louis-San Francisco Railway in their shops at Springfield, Missouri. Here Mr. Scott's efforts were devoted to acquiring experience in and knowledge of the various departments. Having later concentrated his activities on electrical features, he became successively foreman electrician of the St. Louis-San Francisco Railway, traveling electrical inspector and general foreman of the electrical department of the Chicago, Rock Island & Pacific Railway and foreman electrician, electrical supervisor and assistant chief electrician of the Pullman Company, resigning the latter position in March, 1920. In April of the same year he was appointed representative of the Safety Car Heating & Lighting Company with headquarters at Chicago, Illinois, which position he now holds.

Frank J. Hill, chief electrician of the Michigan Central Railroad, was elected president of the Association of Railway Electrical Engineers at the fifteenth annual convention of the Association which was held in

the Hotel La Salle in Chicago, October 21 to 24. Mr. Hill was born in Jackson, Michigan, in 1878. He attended St. John's parochial school until fourteen years of age, at which time he began an apprenticeship at the machinist trade. Later he took up electrical work with the Jackson Light and Power Company, which was the parent company of the Consumers Power Company of Michigan today. In 1904 Mr. Hill entered the service of the Michigan Central Railroad in the electrical department and remained there for six years. At the end of this period he entered the employ of the Pere Marquette Railroad, where he remained for four years. He then returned to the Michigan Central Railroad, and on January 13, 1913, was made chief electrician in which position he is in charge of train lighting, electric welding and train control.

O. A. Neidermyer of the Edison Storage Battery Company of Chicago, has been transferred to the western territory, and will be located at 206 First street, San Francisco, Calif. He will take over the duties of N. W. McMillan, who has been transferred to the Chicago office.

Paul M. Etters, sales engineer of the National Carbon Company, has resigned to become eastern manager of the E. A. Lundy Company, with headquarters at Pittsburgh, Pa. He was born at Bellefonte, Pa., on October 18, 1887, and graduated from Pennsylvania State College with the degree of B. S. in electrical engineering in June, 1909. On July 1 of the same year he entered railway service with the Pennsylvania as a signal apprentice, and three years later was appointed an assistant inspector of signals on the lines east of Pittsburgh. On March 15, 1913, he was appointed assistant signal supervisor on the West Jersey & Seashore, with headquarters at Camden, N. J., and four months later was transferred to the Middle division of the Pennsylvania, with headquarters at Altoona, Pa. On June 1, 1918, he resigned to become electrical engineer of the Hercules Powder Company at Wilmington, Del., being assigned to construction work of the government munition plant at Nitro, W. Va., which position he held until June 16, 1920, when he entered the employ of the Electric Storage Battery Company as sales representative. On January 1, 1923, he entered the employ of the National Carbon Company as sales engineer, which position he has held until his recent appointment.

Russell Murphy has been appointed district sales manager for the Square D Company in the Chicago district. He will be located at 949 Otis Building, 10 South LaSalle St., Chicago. Mr. Murphy was formerly in charge of the Company's Milwaukee territory.

R. J. Parisian has been promoted from Chicago district sales manager to special representative.

Obituary

L. B. MacKenzie, one of the founders of the *Railway Electrical Engineer,* recently died very suddenly in Chicago. Mr. MacKenzie was also the former owner of the Signal Engineer, now known as Railway Signaling, and published by the Simmons-Boardman Publishing Co. He had been identified with the publication business for a number of years, and at the time of his death was president and editor of the Welding Engineer, a paper devoted to the field of autogenous welding.

Trade Publications

Automatic Station Control Equipment, a 27-page bulletin, has recently been issued by the General Electric Company, and is designated as No. 47,731. It describes briefly the uses and advantages of this type of equipment, and is well illustrated. The greater part of the bulletin is given over to a list of installations up to January 1, 1924, giving the name of the company, station, type of apparatus, kilowatt capacity and incoming and outgoing voltage.

The Reliance Electric & Engineering Company, Cleveland, Ohio, in its bulletin No. 2016, recently issued, describes and illustrates the type T heavy duty Reliance planer motors for reversing service. Sectional photographs of the various parts of the motors are shown as well as illustrations in which may be seen their application to large planers in shops.

Sangamo Electric Company, Springfield, Ill., has just issued its bulletin No. 65 entitled "Instrument Transformers." The bulletin illustrates and describes a large number of instrument transformers of various types manufactured by the Sangamo Company. Not only is the commercial side of these transformers explained, but considerable space is devoted to the theory and factors in their design.

The Westinghouse Electric and Manufacturing Company has recently published a 56-page booklet entitled "High Voltage Porcelain Insulators—Their Design and Manufacture." This publication, which is known as S.P. 1690, has been issued for the purpose of presenting information concerning porcelain insulators. A short chapter on the art of pottery is followed by a description of the various manufacturing processes. Photographs, sketches and drawings illustrating all the points are included.

Crouse Hinds Company, Syracuse, N. Y., has recently issued three illustrated folders describing respectively connectors, interlocking safety switch and plug and Wedgtite pipe hangers. The connectors illustrated are those used for joining rigid with flexible conduit. The interlocking switch and plug is an inclosed box containing a switch and fuses with a plug adjustment at the bottom so arranged that it is impossible to withdraw the plug or open the door of the fuse compartment unless switch is open. The Wedgtite hangers are clamps designed especially to support one or more pieces of conduit from I-beams or similar structural iron work.

Creosoted Yellow Pine Poles.—The International Creosoting & Construction Company, Galveston, Tex., has issued a 32 page booklet describing in detail the practices which it follows in the cutting, seasoning, framing and treatment of its southern yellow pine poles. This book let contains an excellent exposition of the qualifications of this timber for pole line construction and describes the manner in which the cutting, seasoning and treatment of these poles are safeguarded to prevent deterioration of the timber. The booklet is illustrated profusely with photographs showing the various steps in the manufacture of International creosoted pine poles and concludes with the specifications for the poles and for their treatment. This booklet contains a large amount of information which will be valuable to every user of poles.

Railway Electrical Engineer

Volume 15 DECEMBER, 1924 No. 12

Train Control on Locomotives

As more train control equipment is installed it becomes increasingly evident that the big end of the maintenance work in connection with it is going to be on the locomotive. The signal departments have succeeded in transferring the indication from the roadside to the locomotive by methods which are inherently dependable, but it is on the locomotive that things are more liable to go wrong. In many of the train control systems the apparatus on the locomotive is of rather delicate construction. This is in most cases necessarily so since the actuating impulses are feeble and must be augmented by the function of sensitive apparatus. All of this means that train control equipment on the locomotive must be given the most careful inspection. Details of the installation must be worked out regarding the size of wire, kind of wire, methods of making terminals, provision against grounding and many other points which do not appear on the circuit plans of the installation. This study of details has been appreciated by some roads to the extent that special train control supervisors have been appointed to relieve the electrical engineer of this intensive study, but where he is not relieved, the electrical engineer must add these duties to his already crowded program. The fact is that the big end of train control is on the locomotive and it will be only through the diligent efforts of those concerned with its maintenance here that it will approach the desired 100 per cent operation.

Railroad Power Plants

Many possibilities and opportunities are often overlooked in connection with the generation and purchase of power by the railroads. Public utility companies by developing large blocks of power can reduce the cost of production to a low figure and also increase dependability of power supply. For this reason there is a justifiable tendency for the railroads to purchase more power when it is needed and to dispense with existing power plants. Dependability is being further insured and costs further reduced by the interconnection of large power systems. In the recently issued report of the Secretary of Commerce the statement is made that 50,000,000 tons of coal could be saved each year in 11 eastern states by a co-ordinated and fully developed electrical power system. Such co-ordination, the report states, would mean a saving of $500,000,000 per annum at an additional capital outlay of $1,250,000,000.

These figures are imposing, but they should not intimidate the railroad man into thinking he can not compete with these practices. He should not complacently wait until he needs power and then request the most convenient utility company to supply his needs. A western railroad recently designed a power plant which included a method whereby the exhaust steam from the plant was used to supply hot water for filling locomotive boilers. This coupled with good power plant design would so reduce the estimated cost of electric power that it was well below the figure offered by an outside power company. The result was that the power company greatly reduced its original quotation and a contract for a year was signed; power is now being purchased, but the power plant has also been built up to a point from which it could be completed in a short space of time. Some boilers were necessary in either case and space was provided for more boilers, turbines and auxiliary apparatus.

The power plant or power supply is a thing apart from other activities in railroad operation. For this reason it is often looked upon as a facility rather than as a part of operation. In general it is given too little attention and there are large unrealized economies to be obtained in the great majority of railroad power plants.

Electric Traction Progress

Supplementing announcements made some time ago, this issue contains descriptions of two types of motor generator locomotives to be used on the Detroit, Toledo & Ironton and the New York, New Haven & Hartford. These locomotives are a radical departure from anything that has been built previously. They are looked upon with disfavor by some because each locomotive must carry a substation consisting of a transformer and a motor-generator set large enough to supply the demands of the traction motors, at full load. At the same time it must be remembered that these locomotives use direct current traction motors with maximum weight efficiency and high tractive effort, that power is received from a high voltage a. c. trolley, that large resistances are eliminated and that motor control is greatly simplified. These characteristics mean minimum line loss, minimum resistance grid loss and high motor and generator efficiency. Accordingly the size of the required substation is reduced.

Strangely enough it is the railroad men and not the manufacturers who are most enthusiastic about the locomotives. Representatives of one manufacturer feel that series d. c. motors should be used on the locomotive and that rotary substations should be located along the right-of-way; automatically operated if desirable. The other

side feels that constant speed a. c. locomotives are best adapted to railroad service because they are a factor which tends to reduce irregularity of train movement by fixed speed operation.

This difference of opinion recalls the old "battle of the systems," in which the advocates of alternating and direct current struggled for supremacy. Such a struggle usually operates against both contestants; there is no railroad on record, with one exception, which decided to electrify and then reversed its decision because of the objections raised by the manufacturers to each others products. Electric operation is installed when demanded by traffic congestion provided the railroad in question is in a financial position to make a major improvement of this character. Many projects have been postponed because such money as was available was needed more for other things. In general railroad finances are now improving and it is almost certain that electrification will be removed from its state of arrested development. Work is now in progress on five railroads and will undoubtedly be started by others in the near future.

The motor generator type locomotives may have inherent limitations which will prevent their being used extensively, but whether they are the best type yet developed or not, their operation will shed much light on the whole problem of electric traction.

Extension Cord Circuits

The use of extension cord circuits in connection with portable lamps, particularly in working around locomotives, is common practice on almost every railroad. The hard use and, it must be admitted, the outrageous abuse which these extension cords frequently receive make it important that the matter of their design and installation be given careful consideration in order to reduce light failures to a minimum and to eliminate the more serious failures of the insulation which may result in electrical shock to the employee using the lamp. So far as the light failures due to faulty cords are concerned this can probably be best overcome by using a heavy reinforced cord and arranging the outlets in such a position relative to the work that it will not be necessary for the cord to lie on the floor where it is liable to injury from the wheels of a passing truck or heavy pieces of iron being dropped upon it. The ordinary wear and tear which result from the cords being dragged around sharp metallic corners can only be offset by using conductors which have a suitable protection to withstand this kind of treatment.

So far as the mechanical protection of the cords is concerned it is just as essential that this be provided for low voltage circuits as for high.

When the personal hazard from electric shock is considered, the matter immediately becomes one for discussion. One road has found that 32-volt extension lamp cord circuits is most satisfactory and has installed a large number of them. This practice, of course, necessitates the use of step-down transformers, but in this particular case the cost of such equipment has been moderate for the reason that these transformers were built by the company itself. There is this to be said about such an installation—the low voltage makes it practically impossible for anyone using such a cord circuit to receive a serious electrical shock. Another method of protecting the user of portable lamps, and the one which is in more general use, is that of running a ground wire with the conductors supplying current to the lamp. In this case, it is practically impossible to receive a shock as every exposed part of the lamp is grounded, and should any wiring defect occur in the lamp itself, the only result would be that the supply wires would be short-circuited to the ground and the fuse or circuit breaker would immediately disconnect all current from the cord. It will be interesting to follow the development of the low voltage cord circuits although it would seem that the present tendency is to avoid the special construction which this type of equipment necessitates.

How About Your Car Illumination

Railway coaches today are much better lighted than they were a decade ago. It is nevertheless true that there is still plenty of room for improvement on many roads. There are still thousands of gas lighted cars in service and many of them are so poorly lighted that it is practically impossible to read a newspaper or if reading is possible at all, it is only at the expense of severe eye strain.

One of the chief difficulties with gas lighted equipment is the great amount of work required in keeping the globes clean. The globes become dirty so quickly that it is almost impossible to keep them in condition for maximum light giving results. Gas lighted cars will probably continue to be used for a long time but their place is in branch line service where the travel is light and certainly not in main line operation where cars are frequently crowded to capacity. Not only is it difficult to keep the gas lamps properly cleaned but there is unquestionably a depreciation in the light giving qualities of the mantles with the result that the combination of the two faults renders this type of illumination most unsatisfactory much of the time.

Where cars are heavily loaded, as in commuter service, gas lighting equipment should be supplanted by electric installations just as rapidly as money can be found for this purpose. It is important in installing electric lighting that proper consideration be given to the foot-candles that will be available on the reading plane. It is possible to install electric equipment which will not be any more satisfactory than the gas lighting units and unless the installation is planned with care, this may easily be the result. It is not unreasonable to say that illumination which is less than 3½ ft. candles on the reading plane, may be classified as inadequate lighting. Many roads make a practice of furnishing much better lighting than this, while on the other hand on some roads the value falls considerably below it.

The truth of the matter is that people have gradually grown accustomed to better illumination in their homes, offices and other public places and it is only logical for them to expect better lighting when they travel. Axle generator equipment will meet this ever increasing demand for more light and any road that is carrying a large passenger traffic can ill afford to persistently antagonize its patrons with inadequate lighting fixtures giving only a small percentage of the light which the traveling public has reason to expect. How about your car illumination?

Pere Marquette Completes New Charging Plant

Facilities Recently Put in Service at Detroit Embody a Number of Unique Features in Designs

AT Detroit, Michigan, the Pere Marquette Railway has just completed a new charging plant for car lighting batteries which embodies several unique features. At this point it is desirable to keep records regarding the amount of charging required by various roads which receive the service of this charging plant. Cars from the Pennsylvania, Wabash, Pullman Company and the Baltimore & Ohio, as well as those of the Pere Marquette, are taken care of in this yard, and the arrangements by means of which the switching is done to register the power consumed by each of these forms one of the most interesting parts of the installation.

Fig. 1—Entrance Cabinet Where 220 Volt, 3 Phase Current Is Brought in for the Operation of the Motor Generator Sets

The power supplied to this plant for the operation of the motor-generator sets is brought from the transformer station located in the yard at 220 volts, 3 phase. The fused service switch and distributing cabinet may be seen in Fig. 1, together with one of the starting compensators for one of the motor-generator sets. There are two G. E. 40 hp., 60 cycle, 3 phase motors each driving a 27 kw. d.c. generator. Two G. E. starting compensators, type C. R. 1,034, are used in connection with these motor-generator sets. Each starting compensator is equipped with a stop push button mounted on the front of the compensator cover.

All of the wire between the incoming cabinet, the compensators, motor-generator sets and switchboard is run in iron conduits under the concrete floor. A general view of the motor-generator sets may be seen in Fig. 2. Fig. 3 shows the left-hand portion of the switchboard. The two panels on the extreme left are the ones to which the current is led from the generators. It will be noted that the two narrow panels at the left carry heavy two pole knife switches. One of these switches is single throw only, while the other is arranged for double throw. Each panel corresponds to one of the motor-generator sets and has its own circuit-breaker at the top of the panel. On the lower portion of these panels are located four watt meters. The upper left-hand meter registers the total d. c. loads from machine No. 1, while the right-hand meter registers that of machine No. 2. The other two meters at the extreme bottom show the kilowatts of current consumed by the Wabash and the Pere Marquette respectively. These meters are all type D-5 Sangamo watt hour meters. The other watt meters which register the current consumed by the Pullman Company and by the Pennsylvania Railroad are shown at the top of the third panel. These are enclosed in large square glass cases and are the Sangamo three-wire type of meter.

By means of the double pole, double throw switch shown on the second panel from the end, it is possible to connect the two generators in series or multiple. When this switch is thrown upward the output of the two machines is in parallel, and when it is thrown downward the two machines operate in series. This latter connection is required in charging cars having 64 volt batteries.

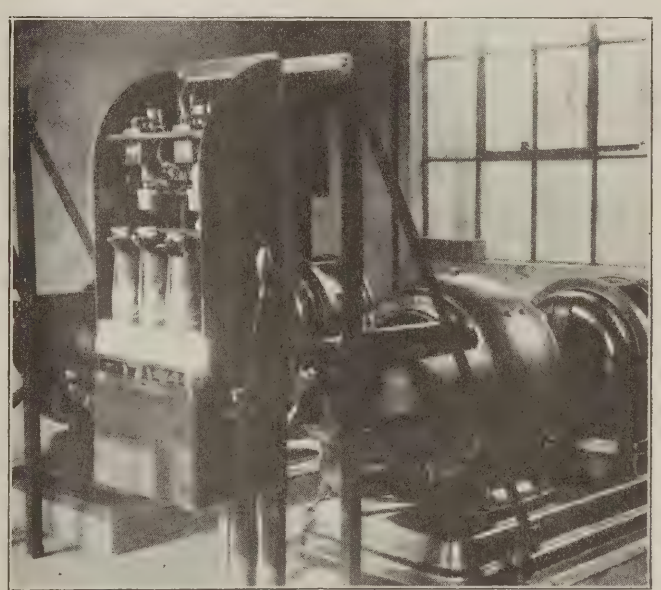


Fig. 2—Starting Compensator with Cover Removed and Arrangement of Motor Generator Sets

Just above these switches are located the hand rheostats for adjusting the field circuits of the generators and still above these are two 0-750 ammeters. The one on the left shows the ammeter output of generator No. 1, and the one on the right, that of generator No. 2. The

second meter does not register, however, when the machines are in series, but each meter registers when the machines are running in parallel.

The voltmeter on the left of the switchboard near the top, which is hardly discernible in the photograph, is so arranged that the voltage of either machine can be taken at any time.

In the extreme right-hand lower part of the third panel a group of receptacles will be seen. There are five rows of four receptacles, and these rows in order from top to bottom are: Pullman, Pennsylvania, Pere Marquette, Wabash and Baltimore & Ohio. It is to these receptacles that the current from the generators finds its way after passing through the circuit-breakers and switches of the other two panels.

The connections of the charging lines are made on the face of the board by means of jumper cables equipped with the proper plugs to fit into these receptacles. In order to continue to follow the circuit through its various

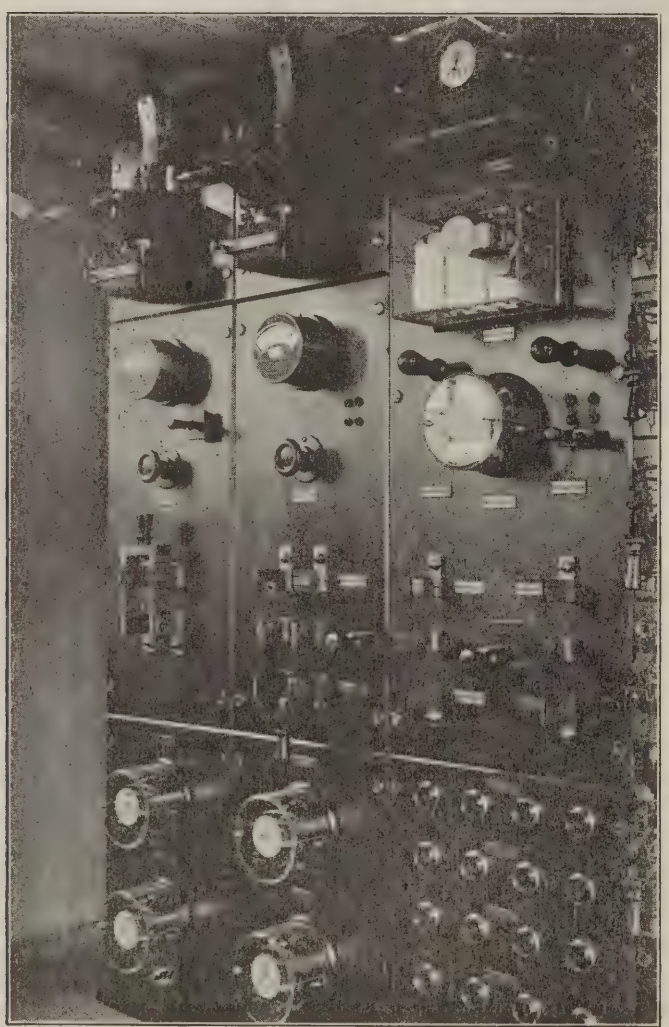


Fig. 3—Left Hand Part of Switchboard

pathways it will be necessary to refer to Fig. 4, which shows the remainder of the switchboard. It will be seen that the left-hand panel of Fig. 4 is the same as the right-hand panel in Fig. 3. In Fig. 4 will be seen ten of the Allen Bradley rheostat control panels which contain in addition to the rheostat adjusting handle two small circuit-breakers. One of these breakers is an overload breaker and the other, an underload breaker. When the breakers of one of these panels are closed and the car is charging, both the voltage and amperage of the car on charge can be easily read by means of a small device attached to the side of the overload circuit-breaker contactor. This device consists of a little metallic wheel which is insulated from the breaker, and which makes contact between the two springs mounted on the panel when the breaker handle is slightly tipped. The slight play of the

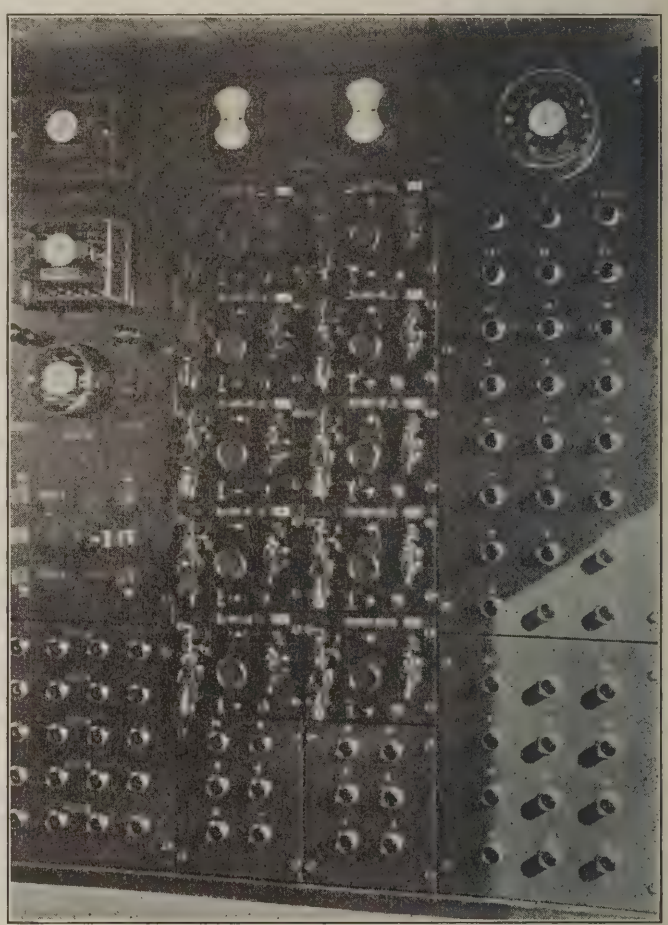


Fig. 4—Right Hand Part of Switchboard

breaker handle makes it easily possible to move it in a vertical direction without in any way affecting its main functions, and this light action is sufficient to close the contacts on the two springs. These springs are connected to the double reading Weston volt-ammeter located at the top of the board. These small circuit-breaker panels each carry one 100-ampere fuse on the positive side of the charging circuit and a small one-ampere fuse which is inserted in the volt ammeter circuit. Each of these boards is also equipped with a small pilot lamp which shows a red light when the panel is in service.

Just below this bank of circuit-breaker panels are two small panels of six receptacles each. It is to these that the other end of the jumper cables previously mentioned are connected. These receptacles in turn connect to the small circuit panels just described. It will be noted that there are 12 receptacles, but only 10 of these are in use, one for each circuit-breaker panel.

After leaving the circuit-breaker panels the current is conducted through the wiring behind the board to another group of receptacles shown in the lower right-hand panel

of Fig. 4. There are also 12 of these shown, but as before only 10 of them are in service.

Immediately above this group there is still another panel of receptacles, 24 in number, which are the terminals of the charging lines leading to the yard. Two of these are spares, however, and one of them leads to the enginehouse, where it is used for charging an Elwell-Parker truck.

The connection between the receptacles in the lower

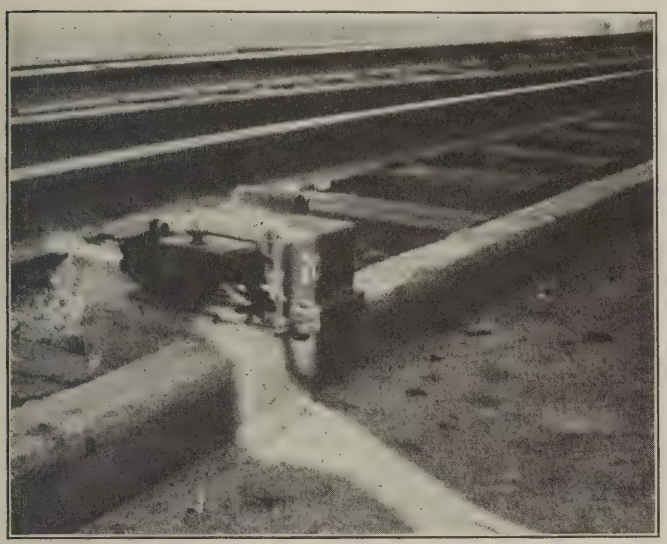


Fig. 5—One of the Terminal Boxes at the End of the Charging Lines

right-hand corner and the receptacles above, which are the terminals of the yard lines, is made by means of jumper cables.

The instrument located at the top of this panel is a a. c. watt-meter which records the total amount of energy consumed in the two motor-generator sets.

On leaving the receptacles on the right-hand panel the

Fig. 6—Putting a Car on Charge—80 Ft. Cables Are Used

yard conductors are led through a tile duct system under three tracks to a line of manholes between the third and fourth track from the building. These manholes are placed between 40 and 50 feet apart. All of the 21 lines, including two large negative or return lines of 750,000 circular mill capacity each, run across from the switchboard to the first manhole. These return lines are tapped so as to extend to all of the other manholes in the yard, while the 21 charging lines branch out and are carried to the various parts of the yard. The charging cables are led from the manholes in iron conduits surrounded by concrete to the charging receptacles, one of which is shown in Fig. 5. In some cases there are two or three of these terminal boxes on one of the charging lines. The terminal box used in this particular construction is manufactured by the Crouse-Hinds Company. It contains two receptacles for charging line plugs and a single receptacle for the 110 volt a. c. line which is used to operate a vacuum cleaner system.

There is a single line of manholes parallel with the first line, three tracks further away from the charging plant. These two lines of manholes, together with the terminal boxes, are sufficient to furnish adequate charging facilities for the entire yard. It has been found that long charging leads from these boxes are best adapted to the service, and leads as long as 80 feet are used for this purpose. Fig. 6 shows one of these leads being connected to a mail car for charging.

The design of the switchboard originated with F. E. Starkweather, electrical engineer for the Pere Marquette, who also supervised the installation of the entire charging plant.

Headlight Maintenance Handled by One Man

By J. C. Moore, C., R. I. & P., Eldon, Mo.

Many accounts have appeared in the *Railway Electrical Engineer* of the helps and methods used in shops at points where major repairs and reclamation work is carried out, but I do not believe that a single account has been published as to methods used at points where only one man is employed. I will try to give an account of the work as it is taken care of at the roundhouse of the Rock Island at Eldon, Mo.

The first thing of a morning is the line-up. This is a list of all engines at the ash pits or in the roundhouse, and is placed on a card with the numbers of all engines that were in the roundhouse at quitting time the day before in a column on the right hand side and all those that have come in since on the left. After this is done, each engine appearing on the left hand side is given an inspection, the extent of which depends on trouble reported and the amount of steam the engine may have. If there is enough steam to operate the turbine it is started, and all lights that are not burning are repaired at once if no material is needed other than a piece of friction tape, which is always carried, and a note made of all bad globes. Where material is needed, a note is made so that no extra trips will be necessary for any of it when the repair is made. All trouble reported by the engineer is written out on slips of paper and placed in front of the engine by the foreman, and these are collected as each engine is inspected, and especial attention given to such work as is requested. Those that are not taken care of at once are placed with notes of material for jobs which will be looked after later. As each machine is inspected, it is also oiled and greased if needing either, and the glass in front and

on sides of headlight case are wiped off as well as marker lamps. After the inspection has been taken care of, the numbers of all passenger engines that will go out during the day are obtained from a blackboard kept for the purpose of showing the progress of the work on each engine and the train it is to be used on. As soon as the fire-builder has marked an engine hot, the lights are given a final test. Between the time the inspection is finished and the first of the four day passengers are marked up, all repairs which were not taken care of at the time of inspection are made on the passengers and such of the freight engines as the time may permit. At this particular point, freight engines seldom leave the roundhouse after the electrician starts the day's work until after the passengers have all left. Two of these usually leave about two and a half hours after the starting time and the other two day passengers leave within an hour of the first two. After this any freight engine that needs heavy repairs is given first attention, while all incoming engines are given inspections as soon as they reach the ash pits. Once each month, each turbine is given a governor inspection. At this time the machine is completely dismantled and the oil wells are cleaned out and the bearings given a thorough cleaning, as well as all other parts of the machine. The machine is then re-assembled and such parts as might cause a failure within another month are discarded and new ones substituted. The governor is then adjusted so as to give a voltage of 31 volts, and if the engine is in passenger service, the headlight globe is removed and a new one put in. Those removed are not thrown away, but are used on other engines which are in freight service. The reason for changing these bulbs is that experience has shown that where a globe burned out or broke while the engine was in service, that in the majority of cases it had been in the headlight for over a month. By keeping fresh bulbs in the headlights and setting the governor every month the failure of the headlights is kept at a minimum, and in addition the engineer is provided with a properly focused light as a screen is placed before an engine and the headlight focused if the bulb is put in at the time the engine is in the roundhouse. The screen used has been previously described in the *Railway Electrical Engineer,* so that a description is not necessary at this time. A great many globes that are burned out are the result of carelessness on the part of the engineer, as the action of some turbines in speeding up and consequently increasing the voltage when the headlight is thrown on suddenly will quite often burn out the bulb, where the action of the turbine would be much more gradual if the headlight were first placed on "dim" and then on "full."

The best way to take care of emergencies is to be prepared for them before they occur, and for this purpose the three sizes of bulbs used on engines are kept in a rack which is located at a convenient point. When a globe is wanted in a hurry, it is taken off this rack and then later on it is replaced by one from the storeroom. Fuse wire and fuse plugs are also kept handy for the same purpose.

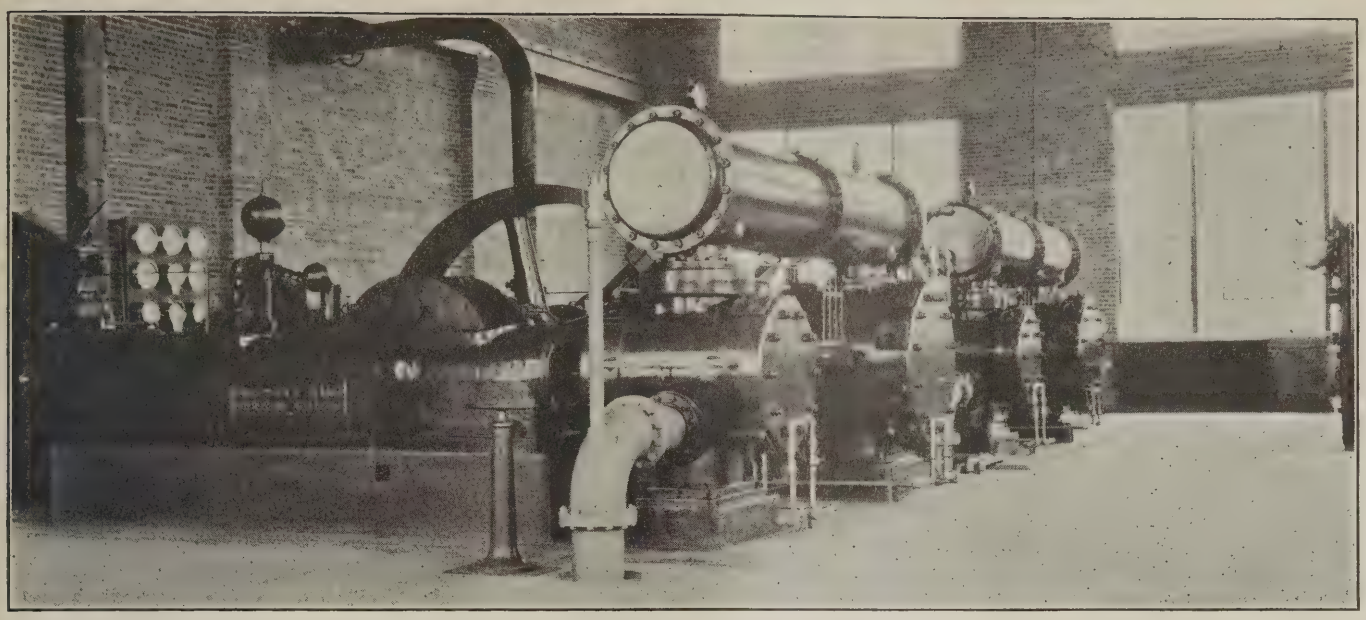
While this article has dealt with the work only as it concerns the engines, this is by no means all that the electrician has to look after. There is an electric welder and a forty horse-power motor as well as the lights in the various buildings and yards to be looked after. While the writer was located at another point on the Rock Island instructions were issued that care should be taken to see that switches and branch lines were not overfused. To make sure that all lines were properly fused a survey was made, and as a result the size wire in every circuit was obtained as well as the normal and maximum loads. To make sure that the fuse blocks would be provided with the proper fuse after this work was done, the proper size was stenciled on the cover of every switch or fuse box. This number was placed directly opposite the fuse referred to so that there was no chance for anyone making a mistake. This system of marking fuse boxes was later adopted as standard for the Rock Island System. A great many fires could no doubt be prevented if all branch lighting circuits were properly fused, and they would be much more likely to be equipped with the right fuse if the size were marked on the box in this manner.

Once each month a complete check is made of the number of electric lights which are burning in the roundhouse and in the yards as well as the machine shop, where the electric lights are used the most. For a time it was found extremely difficult to prevent the removal of the bulbs from the sockets. In the roundhouse they were placed about ten feet above the ground and provided with guards which required a key to open. This proved to be useless as the globes were removed anyway. In some cases the guard was cut around the lower part, and in others it was broken or cut at the top and the whole guard removed. It was then decided to solder the globes in place. To do this a small piece was cut out of the weather proof sockets which were used, and then the solder applied with an iron. The machine shop is equipped with porcelain sockets of a type that can be taken apart so as to leave only half the outside insulation in place, and can easily be soldered and then put back together. To remove an old globe from either socket requires a blow torch, and as soon as it became generally known that all bulbs were soldered the attempts to remove the bulbs were quickly given up. The monthly consumption of 60 watt globes dropped from about a hundred and twenty-five to fifteen or twenty a month.

The motor which is located at the coal chute is examined regularly every week, and at this time the controller is examined and all rough fingers and contacts are smoothed up and greased very lightly with vaseline. At least once each month the air gap is gaged to make sure the bearings are o. k. While this motor is equipped with a babbit bearing it has a rather small air gap, and this is watched to see that the bearings have not worn down enough to allow the rotor to touch the field. The welder, a U. S. L. 200 amp. a.c.-d.c. machine is given similar treatment with the addition of caring for the two commutators. This machine is overhauled twice a year, at which time the commutators are under-cut and all bearings taken out and cleaned.

Locomotive work is given preference over all other, the motors come next and then the lights, and by utilizing the times when work is usually slack to put motors and lights in good shape all are kept in good order.

Electrical goods exported from the United States during October, 1924, exceeded in value those exported during the preceding month by over three-quarters of a million dollars, according to preliminary figures just made available by the Electrical Division of the Department of Commerce. The actual value in October, 1924, was $6,864,232.



The Engine Room of the Chicago, Burlington & Quincy Power Plant at Denver, Colo.

C. B. & Q. Builds Model Coal Burning Power Plant

Steam Generated for Shop Requirements and for Compressing Air
Electric Power is Purchased

A POWER plant for serving the needs of the new Chicago, Burlington & Quincy shops at Denver, Col., has recently been completed. Steam generated in the plant is used for compressing air, for heating, for operating steam hammers in the blacksmith shop, etc. Compressed air is used operating air tools and for pumping. Electric power is purchased from the Public Service Company of Colorado and used for operating motors and for lighting. The facilities served by the power house include a machine and erecting shop, blacksmith shop, boiler shop, oil house, and store house and offices. Facilities are available for classified repairs to 200 locomotives and running repairs to 50 locomotives per month. The machine and erecting shop contained in the largest of the several shop buildings, is 509 ft. long and 243 ft. wide.

The power plant is a brick building 128 ft. long by 89 ft. wide and about 60 ft. high at the highest point. The concrete stack is 250 ft. high with an inside diameter of 12 ft. at the top. The building is well lighted during the daytime by large metal sash windows. All of the equipment is located on the operating floor except for the coal bunkers above the boilers and for the ash handling equipment, pumps, lockers, thermostatically controlled showers, etc., which are located in the basement.

Coal and Ash Handling Equipment

Cars delivering coal or carrying away ashes from the plant are left on a track which parallels one side of the plant. Services of a switch engine are minimized by a motor driven winch which is used for spotting cars. Push-buttons for starting and stopping the 7½ hp. motor which drives the winch are located on the side of the winch within easy reach of the operator.

The coal is dropped from the car, through a grating into a hopper. The grating is removed when lump or nut coal is unloaded. The coal from the hopper falls on a conveyor apron and the conveyor apron which is in reality a short conveyor discharges the coal directly to the main conveyor or through a crusher to the conveyor if crushing is required.

The one conveyor which is a Link Belt pivoted bucket type is used for handling both coal and ashes. From the crusher it runs vertically inside a sheet iron housing to the roof, then horizontally across the top of the ash hopper and over the top of the coal bunker to the opposite side of the power house, then down to a pit in the basement floor. Finally it runs along this pit between the boilers back to the coal hopper. Trips can be set so that the conveyor buckets will dump their load into any part of the coal bunkers or into the ash hopper.

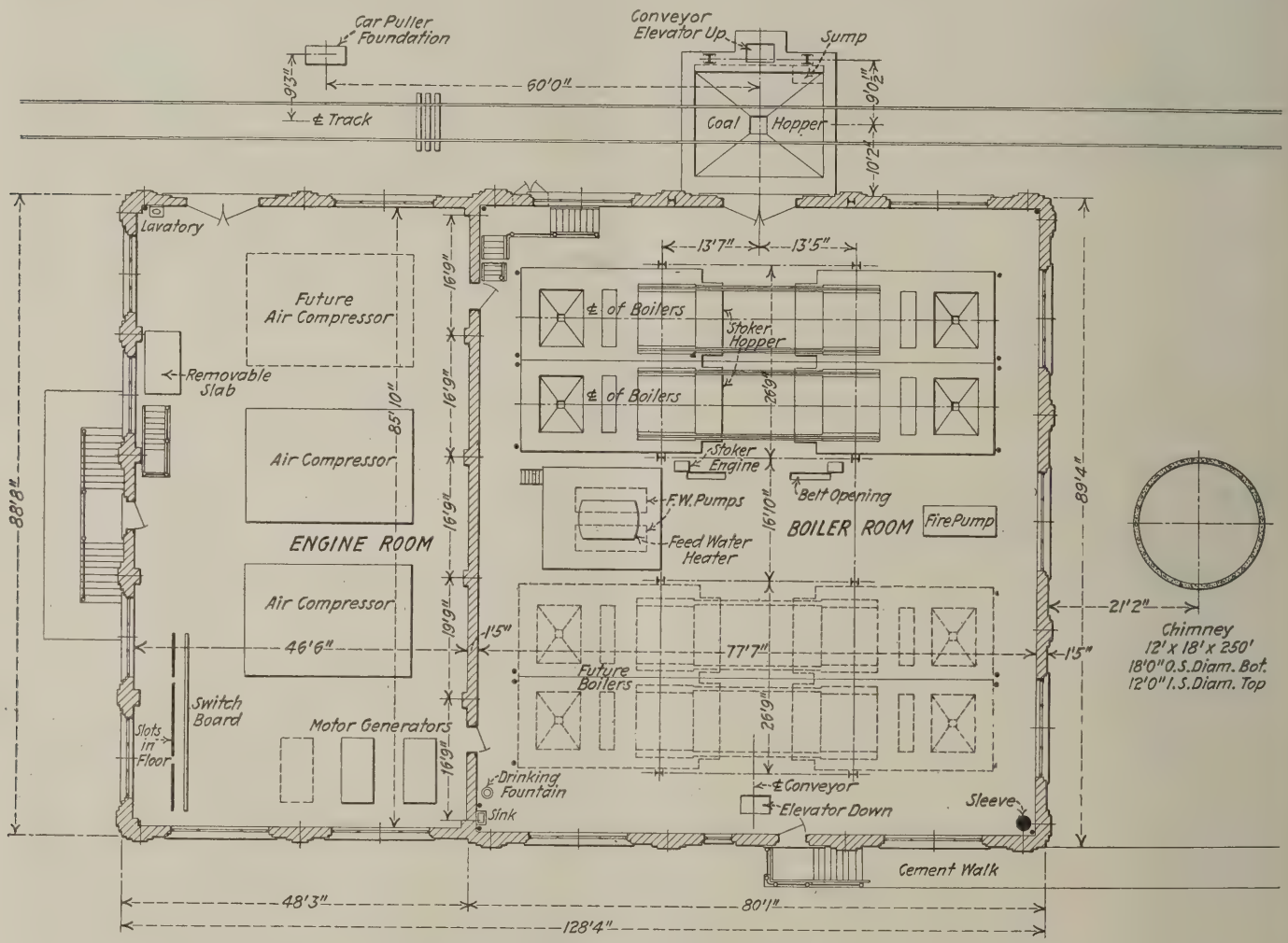
When coal is being taken from the cars the conveyor buckets are tripped over the coal bunker. This bunker has four compartments and is located directly over the firing aisle between boilers; it has a capacity of 250 tons. From the bunker the coal can be discharged into a weigh lorry which is suspended from a beam over the center of the firing aisle and which can be moved manually to any desired position so as to deliver coal to any one of the four boilers. The lorry is equipped with Kron scales and has a capacity of 2,000 lb.

From the lorry the coal is dropped into any one of the boiler coal hoppers. These hoppers in turn deliver the coal to Geco chain grates. Ashes fall off the end of the chain grates into ash pits under the boilers where they are kept wet by sprays controlled from the boiler fronts. Ashes are disposed of at the end of each shift. They are raked out of the ash pits onto the conveyor which carries

them to the ash hopper, from which they are dropped into cars on the loading track. The hopper capacity is 100 tons.

Green or partly burned coal which passes through the grates, falls into a dry pit above the ash pit. When a sufficient amount of these droppings have collected they are scraped out into a portable chute down which they slide onto the conveyor. This carries them back to the coal bunkers. The accumulation of combustion ash in the combustion chamber falls into a hopper and is removed to wheelbarrows through chutes in the basement. These chutes have self-sealing gates. The ash is wheeled to the conveyer and conveyed to the ash hopper.

Four hundred forty volt alternating current motors are



Plan Showing the Operating Floor of the Power House

pressure and are operated normally at 150 lb. The fireboxes are provided with Green fuel retarders. These in effect are an adjustable section of the water back located over the inner end of the grate. This is adjusted according to the thickness of the fire so that an excess of air does not go over the fire to the stack. It also prevents green coal from being carried over the end of the grate.

Precision draft gages show draft at the last pass and draft over the fire. The draft and the stoker speed are controlled by an A-Jacks automatic regulator governed by boiler pressure. The amount of draft is maintained at the minimum which will burn all of the coal by the time it reaches the back of the grate. The four stokers used to drive the crusher and conveyer. A 30 hp. motor is used for the crusher, a 5 hp. motor for the conveyor apron and a 30 hp. motor located just under the roof drives the conveyor. The three motors are controlled by industrial controller automatic compensators. The conveyor can be started or stopped from the basement or from the runway over the coal bunkers. It is interlocked with the conveyor apron so that the conveyor can be operated separately, but the apron cannot be started unless the conveyor is running.

Boilers

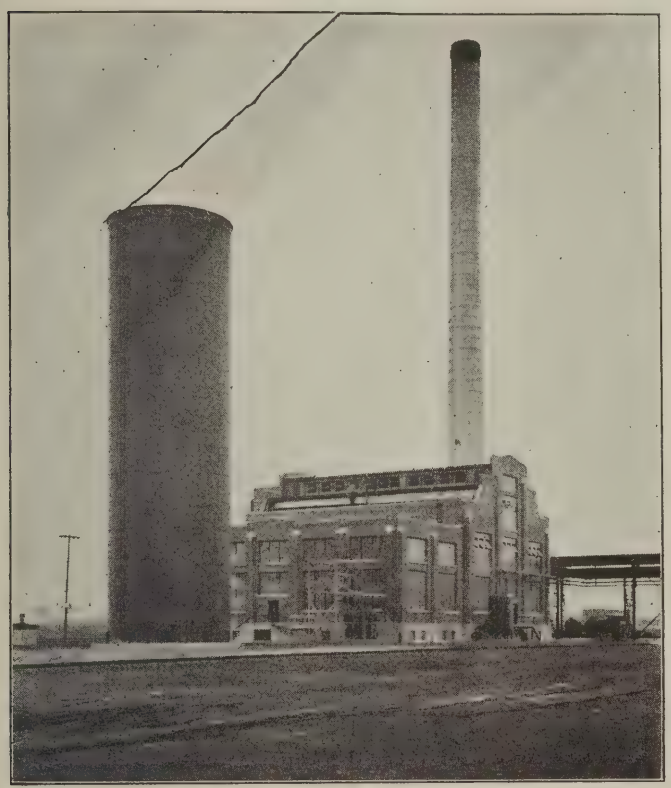
The boiler room is equipped with four 406 b.hp. Heine water tube boilers. They are designed to carry 180 lb. are driven by two Green stoker engines placed on opposite sides of the firing aisle. A cross belt under the boiler room floor connects the stokers on opposite sides of the aisle so that either engine can be used to drive any one or all four of the stokers.

The boilers are equipped with dual feed lines, Reliance high and low water alarms, Green high pressure water backs, Foster superheaters, steam gages and Republic indicating flowmeters which show flow of steam from each boiler. Automatic, non-return stop valves are also placed in the header lines at the boilers. Blow-off lines have double valves; two in series. The flue sheets have key caps instead of gasket plates and the superheaters are provided with Bayer steam soot blowers. Provision has been

made for doubling the capacity of the boiler room when it becomes necessary.

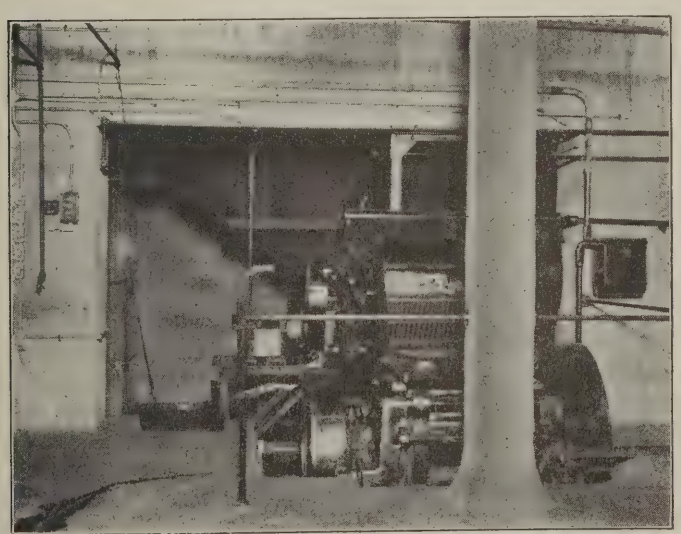
Water Supply

All water used in the shops and in the power house is taken from two wells 550 ft. deep by air lifts. Each lift



The Power Plant Showing Standpipe, Outdoor Substation and Air Receivers

has a capacity of 300 gal. per min. The water is discharged from the lift into a two-part cistern, one side of which has a capacity of 10,000 gal. and the other 20,000

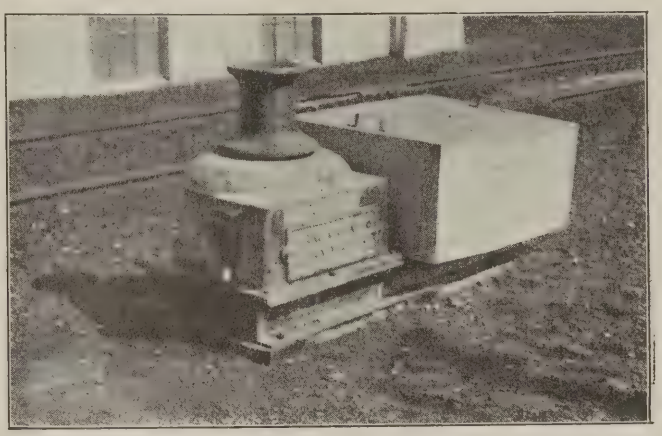


Coal Crusher and Coal Receiving Hopper

gal. Water from the lifts flow into the smaller side and overflows into the larger. Drinking water is pumped from the smaller side of the cistern through the drinking water supply lines in the shops and back into the larger section of the cistern. This water is kept in circulation so that it is always cool.

A duplex steam pump located in the basement of the power house pumps water from the 20,000 gal. cistern to a standpipe having a capacity of 500,000 gal. A motor driven centrifugal pump is used as a standby for the same purpose.

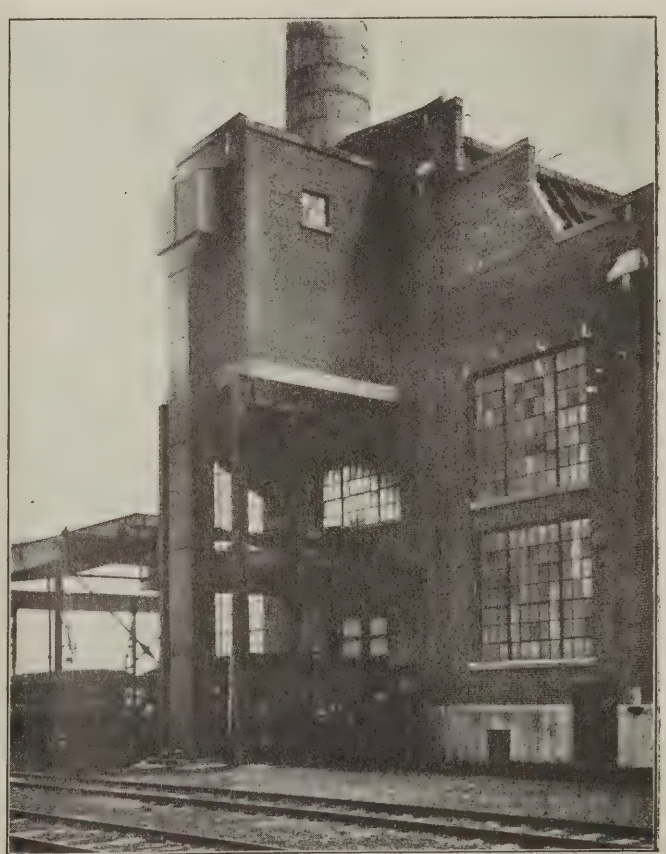
Two duplex feed water pumps in the boiler room take water from a Worthington open heater and deliver water



Winch Used for Spotting Cars on Loading Track

to the boilers at a temperature of 210 to 212 deg. F. The steam end of the feed pumps are equipped with pressure regulators so that throttling of the discharge line will not cause excess pressure to blow out gaskets in the feed water line.

The fire pump also located in the boiler room is a



Side View of Power Plant Showing Ash Hopper, Conveyor Housing and Car in Position for Loading Ash or Unloading Coal.

Worthington duplex with a capacity of 1,500 gal. per min. at 150 lb.

Water, Steam and Air Lines

All high pressure steam lines are painted black, exhaust steam lines orange, feedwater lines maroon, return lines green and air lines brown.

Exhaust steam is used for heating the shop buildings and for heating water. Live steam can also be used for heating. Condensate is returned to the receiving tank and through the feedwater heater back to the boilers.

Steam hammers in the blacksmith shop and all other steam driven apparatus is exhausted into the low pressure lines. Low pressure steam line pressure is about 4 lb. and about 5 per cent of make-up water is required.

The heating of the shop is accomplished by both direct and indirect radiation; the indirect system being used in the machine and erecting shop and in the boiler shop. The fans used for indirect heating are steam driven and all steam condensed in the shops is taken out of the exhaust line and pumped by separate pumps to the receiving tank in the power house boiler room.

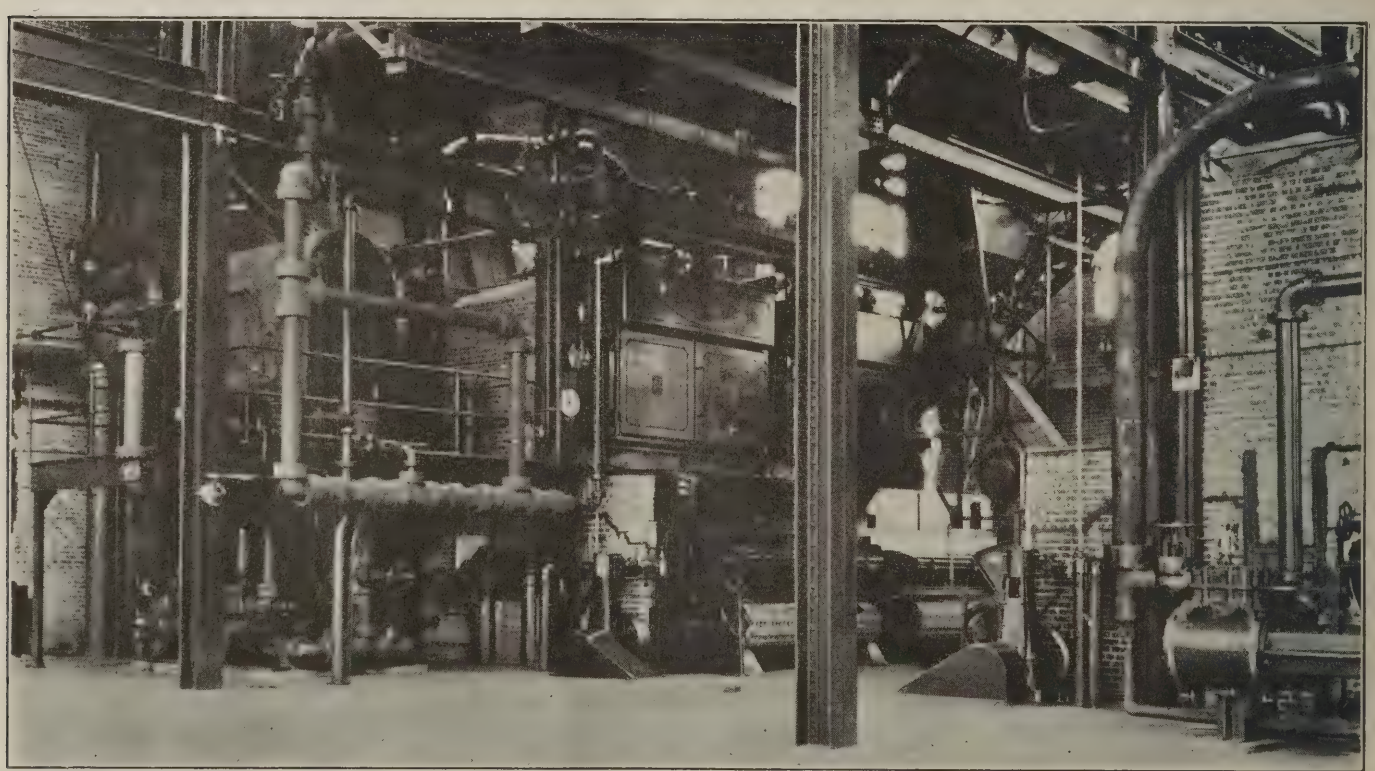
Walworth valves, with bypass feature to prevent possible damage caused by opening large valves, are used on the high pressure steam lines. These lines are bled by Crane tilting steam traps, one of the traps being placed just ahead of the fire pump so that the pump is always ready for instant use. The boiler feed water line is protected by pressure relief valves.

Engine Room

The apparatus in the engine room consists essentially of two steam driven air compressers, two motor generator sets, a gage board, a flow meter, a switchboard and an overhead crane. The air compressors are Ingersoll Rand, cross-compound, two-stage compressors having a capacity of 3,444 cu. ft. per min. The steam cylinders are 34 in. x 24 in. and 18 in. x 24 in. The air cylinders are 32 in. x 24 in. and 19 in. x 24 in. They have overspeed safety stops and the compressors as well as all reciprocating pumps are equipped with Hills-McCanna force feed lubricators. Air is taken in from outside through Midwest capillary air filters located just below the engine room floor and is discharged into two air receivers placed outside of the power house.

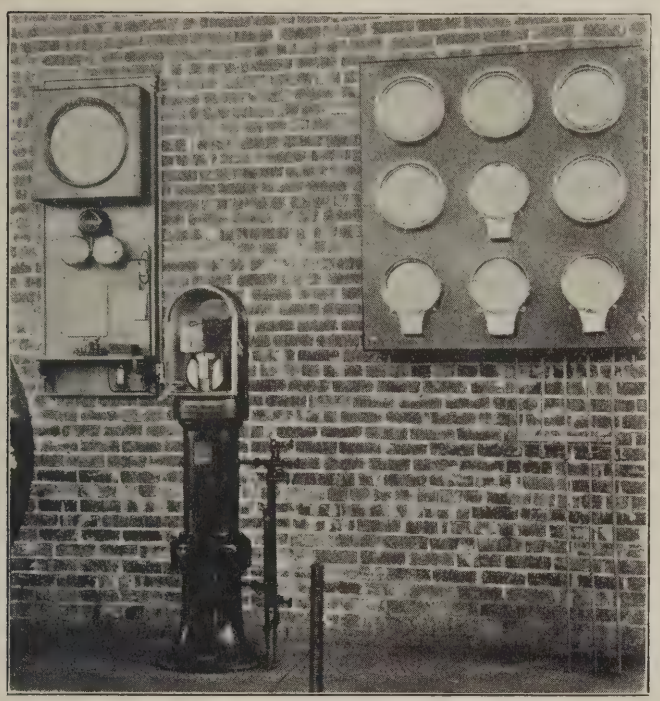
Steam and Electric Pumps for Filling Standpipe Located in the Basement Below the Switchboard

The gages on the gage board show boiler pressure, exhaust steam pressure, air pressure, standpipe pressure and fire line pressure. The standpipe gage shows both pounds pressure and head of water in feet. The four curve draw-



The Boiler Room. Feed Pumps and Heater Are Shown at the Left and a Part of the Fire Pump at the Right

ing meters record degrees superheat, feed water temperature, boiler pressure and flue gas temperature. The flowmeter is a Simplex venturi recording and integrating flowmeter which records rate of flow and total flow of boiler feed water. A 10-ton manually operated Conco crane serves the entire engine room.



Venturi Flow Meter and Gage Board

Electric Power Supply

All electric power is purchased from the Public Service Company of Colorado. It is received as three phase, 13,200-volt, 60-cycle 3-phase alternating current power at an outdoor substation alongside the power house. In the substation the voltage is stepped down to 440 and carried into the power house through lead cable in 4-in. rigid metal conduit.

The substation equipment which is enclosed in a non-climable type fence, consists of air switches, choke coils, potential and current transformers, General Electric oxide film lightning arresters, and three, 333 k.v.a., 13,200 400-volt Westinghouse power transformers. The power is metered on the high voltage side ahead of the transformers.

The 440-volt power is controlled and distributed at the switchboard in the power house. Direct current power for cranes, variable speed motors, etc., is provided by the two motor generator sets. The sets are identical and one consists of a General Electric 300 h.p., 440-volt, 60 cycle, 1,200 r.p.m. synchronous motor driving a General Electric 200 k.w., 250-volt, direct current generator.

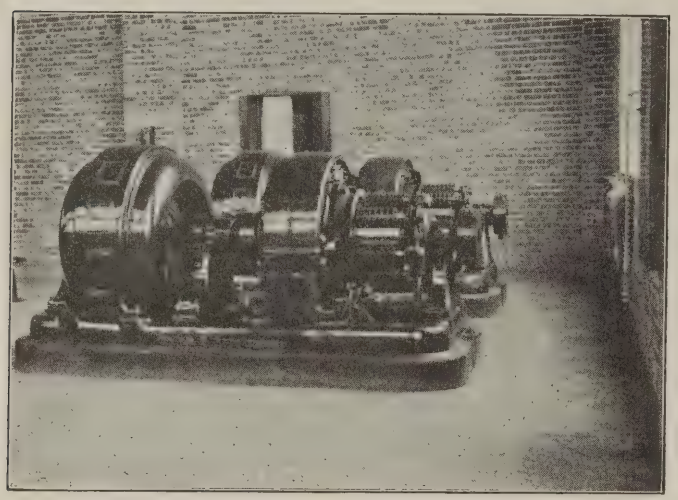
There are 13 panels in the switchboard. No. 1 panel on the left includes main service switch, an indicating ammeter, indicating volt-meter, recording wattmeter and integrating wattmeter. One of the motor generator sets is controlled from the second panel which is equipped with a double-throw oil switch, an a. c. and a d. c. ammeter, power factor meter, rheostat and motor field switch. The other set is similarly controlled from the third panel. The fourth panel is a spare. Panels 5, 6 and 7 control the circuits which serve the machine and erecting shop, the blacksmith and boiler shops and the power house, respectively. Each of these panels has a three phase oil switch for the power circuit, an air switch for the lighting circuit and an indicating ammeter to show the load. Panel No. 8 is blank. Panels No. 9 and 10 control the d. c. circuits from the motor generator sets. Panel No. 12 controls the crane circuits and direct current power circuits in the machine and erecting shop. It is equipped with two circuit breakers, two switches, two ammeters and lamps to indicate a possible grounded circuit. Panel No. 13 is the same as No. 12 except that the left hand circuit controls the yard crane circuit while the right hand circuit is a spare.

The Switchboard

The power is carried from the power house to the shops by lead cables in clay duct.

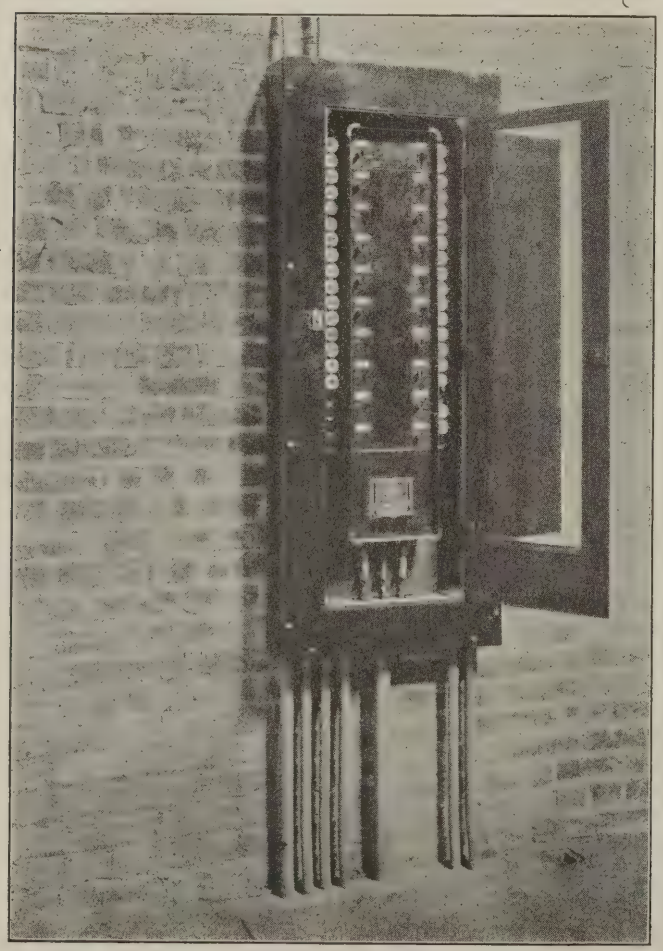
Lighting

General lighting in the engine room is furnished by ten bowl type Benjamin porcelain enameled steel reflectors



The Motor Generator Sets

fitted with 300 watt type C lamps. These units are controlled by five switches located in a lighting cabinet on the wall of the engine room near the motor generator sets. There are five extension outlets spaced about evenly about the wall five feet above the floor and the main entrance and stairway is lighted by two 60-watt lamps in 7-in. Monoglass balls supported on King cast iron weatherproof brackets.



Boiler Room Lighting Control Panel

The firing aisle in the boiler room is lighted by two rows of six units each mounted just in front of the boilers at a height of 24½ ft. The units are bowl type porcelain enameled steel reflectors fitted with 200 watt lamps. Four 100-watt bracket lights in type K condulets light the space back of each row of boilers and 40 watt lamps in Oliver type LCB 45 reflectors are used for gage and water glass lights on the boiler heads. Twelve extension outlets are located on the walls and on columns near the firing aisle. Two 100-watt lamps in R. L. M. porcelain enameled steel reflectors mounted 16 ft. above the ground are used to light the loading and unloading track. Seven 60-watt lamps suspended on cord and protected by Mathews lamp guards are used to light the conveyor platform and stairway while R. L. M. reflectors fitted with a 200-watt and a 100-watt lamp respectively are mounted over the fire pump and feed water heater. All boiler room lights are controlled from a panel located near the outside entrance.

The greater part of the basement is lighted by 60-watt lamps with porcelain sockets and guards hung on reinforced cord. The space over the conveyor is lighted by 100-watt R. L. M. reflectors while out-of-the-way places are lighted by 60-watt lamps in V. V. Fittings Co. vapor proof fittings. Basement lights are controlled from a cabinet near the stairway.

E. J. & E. Equips 30 Locomotives for Train Control

THE Miller Train Control Corporation has recently completed a contract for the Elgin, Joliet & Eastern, equipping 30 engines with an automatic stop. This work was begun on August 21, and completed September 29, 1924, requiring 33 working days. The E. J. & E. engines which are equipped are of the large Mikado type used to haul their long heavy drag coal trains over the Chicago & Eastern Illinois tracks from the Illinois mines to the industrial districts near Chicago.

The device as installed consists of the straight automatic stop, with permissive feature in accordance with the provisions of the latest order of the Interstate Commerce Commission. This feature, considered highly desirable, according to the testimony of many railway companies, permits the engineman, if alert, to forestall an automatic brake application at de-energized ramps.

On account of the simplicity of design and ease of application of this device, one mechanic and helper and one pipe fitter and helper were enabled to equip these engines at the rate of practically one engine each day, and no power was held out of service on account of applying the device.

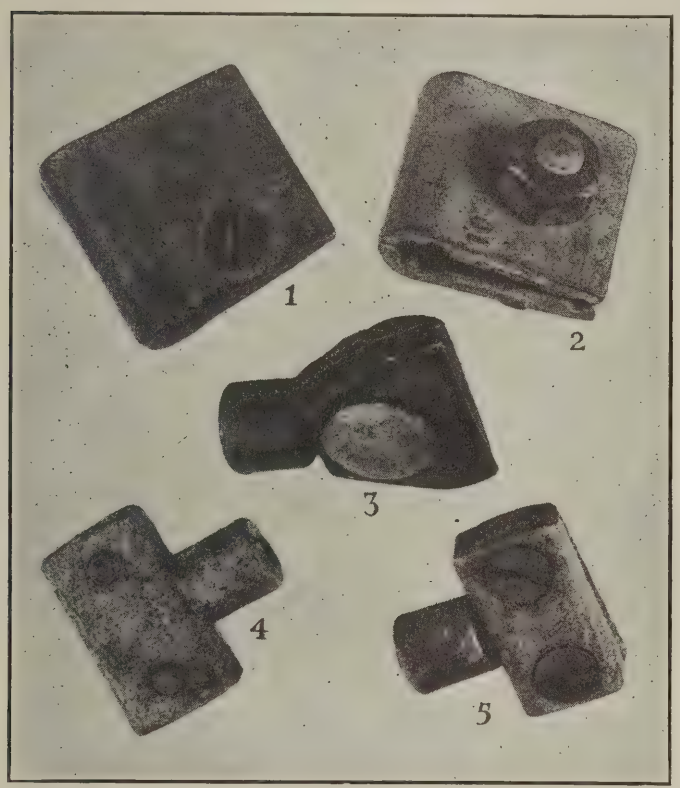
Existing standards of street lighting practice in the United States were studied by the Bureau of Standards and reported at the Annual Convention of the Illuminating Engineering Society. Questionnaires were sent to the 730 cities listed in the census returns as having populations between 10,000 and 500,000, and replies were received from 362.

Contact System for Virginian Electrification

Entire Construction Including Contact Wire, Messenger and Fittings to Be Non-Ferrous Material

By C. L. Hancock
Bridgeport Brass Company

A GENERAL announcement of the decision of the Virginian Railway to electrify its lines between Mullins, W. Va., and Roanoke, Va., came simultaneously with the report that a contract had been awarded The Westinghouse Electric & Manufacturing Company



Type of Clips on the New York, New Haven & Hartford. 1. Two-Screw Galvanized Malleable Intermediate Clip. 2. Modified Intermediate Clip Which Replaced Two-Screw Clip. 4 and 5. Earliest Type of Galvanized Malleable Hanger Clip. 3. Modified Hanger Clip Which Replaced Two-Screw Clip

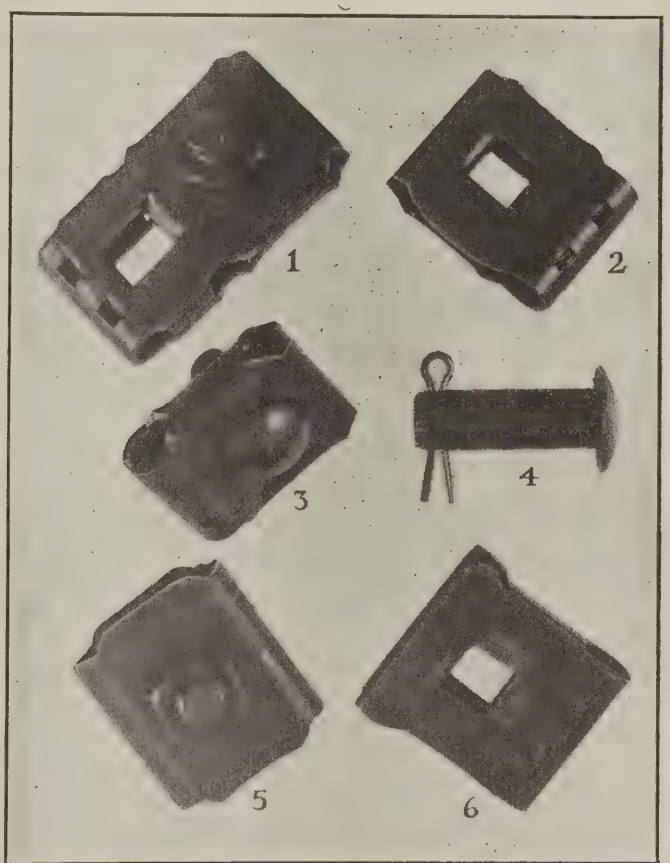
for the purchase of the necessary motive power and power generating equipment sufficient for the handling of its entire tonange by electric locomotives. It was also announced that the propulsion system for the supplying of power to the locomotives would be a 22,000-volt single-phase line of the catenary type with a single contact wire and auxiliary feeder supply adjacent to the tracks, operating initially at 11,000 volts. The fact that this road, built to exceptional engineering standards, has always been noted for its operation with the largest capacity equipment and most powerful locomotives in the world, called for electrification with a big factor of safety in the overhead.

Catenary Construction Developed on the New Haven

Early designs of electric locomotives and overhead contact systems had of necessity to be based on experimentation rather than actual operating experience and these facilities were modified as experience accumulated. Much of the progress that has been made is due to the operating experience of the pioneer steam roads that early adopted electrification. The New York, New Haven & Hartford is a notable example.

The first difficulties experienced on the New Haven were had very shortly after operation was instituted. Trouble was caused by hard spots at points of suspension of the contact wire and excessive wear of the copper contact wire throughout its entire length.

"Hard spots" were practically eliminated by installing a new contact wire directly under the original copper trolley

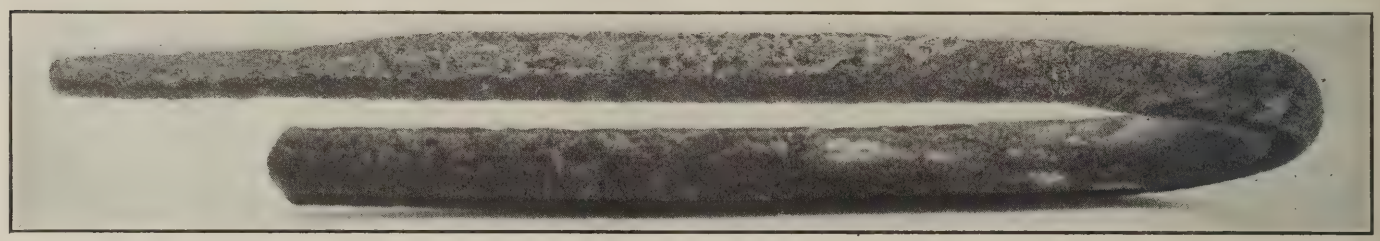


Modern Types of Clips. 1. Sheet Phono Clip, Norfolk & Western. 2. Sheet Phono Clip Used to Replace One-Bolt Cast Malleable Clip, New Haven. 3. Same as No. 2. 5. Sheet Phono Clip, Norfolk & Western. 6. Cast Bronze Clip, Pennsylvania

wire suspending it with clips placed midway between the original suspension hangers. The result was that as no part of the trolley contact wire was held rigidly, the locomotive pantagraphs in passing under the wire found no point where the pantagraph could pound and bounce.

Experience soon indicated that copper wire was too soft to resist the mechanical action of the pantagraph and that

it was necessary to find a material with greater hardness and toughness. Steel trolley wire seemed to possess these qualifications since conductivity was not important as there was a copper wire directly over it and clipped to it at intervals of ten feet. Corrosion troubles were not seriously considered since much of the steel wire then in service had been used only on street railway lines and then coincidentally in dry climates and away from corrosive gases. Apparently the answer had been found to both "hard spots" and long life, and the problem of electric



A Sample of 0000 Grooved Steel Contact Wire, Showing Combined Effect of Corrosion and Wear

operation of steam lines in so far as the distribution system was concerned was solved.

It was not many years, however, before a new and probably the most serious situation manifested itself. This was the corrosion of the messenger wire, hangers, clips and steel contact wire; it being most severe on the contact wire. The trouble finally was determined to be due to a combination of atmospheric conditions and exhaust from the steam locomotives. This corrosion once well started developed rapidly.

Investigations were instituted to find a contact wire which would be non-corrosive and at the same time afford long life since the cost of removing from service long sections of tracks for wire renewals at relatively short intervals of time was recognized as a serious matter from an operating standpoint. Phono-Electric wire was selected by the New Haven for this purpose.

In designing the earlier overhead contact system, electrical engineers had in mind that where dual steam and electric operation was in effect, corrosion of ferrous portions of distribution systems would require some measure to prolong the life of the overhead material. Galvanizing and painting of all ferrous parts was resorted to which, of course, somewhat retarded the corrosion but under normal conditions did not last more than five years. Subsequent painting seriously interfered with traffic and also was expensive.

Virginian Adopts Non-Ferrous Construction

Consideration then began to be given to the possibilities of using non-ferrous material for messenger wires and fittings. When the Virginian electrification distribution system was under consideration investigations where conducted by Gibbs & Hill into the merits of this product. As consulting engineers and contractors for that railroad, they finally recommended the use of Phono-Electric contact wire and in addition Phono-Hi-Strength messenger wire and further decided to employ Phono-Electric for the fabrication of hanger rods and messenger clips throughout, thereby providing a complete non-ferrous catenary system from pantagraph shoe to insulators, the first all non-ferrous construction of its kind in the country.

On account of the high currents which the grades and extraordinarily heavy trains will require, it was found necessary to provide additional conductivity over that available with the usual type of catenary construction and this was supplied by the use of a composite cable made up of Phono-Hi-Strength strands for tensile strength and special hard-drawn copper wires stranded together to provide both adequate strength and conductivity. The use of composite messenger cables for use in catenary construction is the latest new development in the railroad field, though it has been used for transmission lines for a number of years. The coefficients of expansion of Phono-Hi-Strength and copper are practically identical. This simplifies to a considerable extent the possibilities of composite cables for the Virginian overhead construction.

The present plans call for wire made up as follows:

A composite cable composed of 19 strands, the outer layer of hard-drawn copper wire.

The seven wires composing the core cable shall be as follows:

Item	A	B	C	D
Strands high strength bronze ...	7	7	7	7
Strands hard drawn copper.....	12	12	.....	.....
Diameter of wires, inches.....	.145	.111	.124	.147
Breaking strength, complete cable, pounds	25,000	15,000	10,000	14,000
Size of cables, approx. dia.....	.725	.555	.372	.441
Resistance per 1,000 ft. at 20 deg. C.	.0399	.0676	.741	.528
Equivalent circular mills copper..	270,000	159,000	13,900	19,650
Weight per 1,000 ft., lbs.....	1,236	723	332	467
Min. length of cable on reel....	3,000'	2,600'	4,200'	3,000'

All composite cable is to be stranded concentrically with a pitch of not less than 12 and not more than 16 times the diameter of the layer.

Tests upon sections of individual wires containing brazes made before final drawing must show not less than 95 per cent of the tensile strength of the unbrazed wire.

Underwood & Underwood

U. S. Troops Accompanying International Train Through China's War Zone

Elementary Theory of Alternating Current

A Series of Practical Articles Explaining a Difficult Subject in a Simple Manner

By K. C. Graham

Part VII. Transformers

THE most important single factor in the marvelous advance of alternating current has been the transformer. It has made possible such a large saving in the cost of transmission of alternating current over that of direct current that, for anything but the shortest distances, there is no comparison between the two. It shall be our purpose, in this chapter, to discover how this has been brought about.

Fig. 55 (a) shows the simple inductive circuit with which we are already quite familiar. Current flows

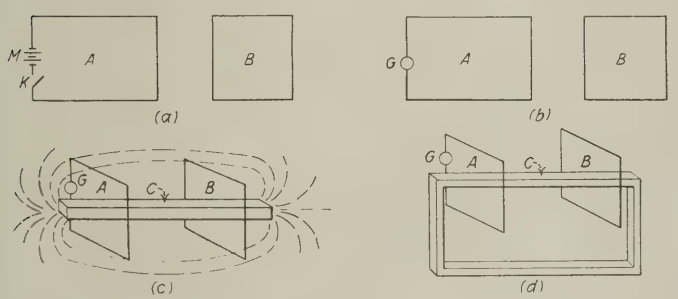


Fig. 55

through loop A when key K is pressed, and the magnetic lines emanating from the wire cut across the conductors of B thereby causing a current to flow in B. If the battery and key are replaced by the alternating current generator G as in Fig. 55 (b), the same result is obtained as the current flow changes from one direction to the other. The flux spreading out from the loop A is forced to pass over a path made up entirely of air which, as compared to iron, has a relatively high magnetic resistance. If a piece of iron C be passed through both of the loops as in view Fig. 55 (c) the magnetic flux will be greatly increased but it will be noted that the path over which the lines pass is still largely made up of the high resistant air. Therefore we may improve the conductiveness, or permeability, of the path by providing a closed path made up entirely of iron as in view Fig. 55 (d). After studying the figures one might ask how any lines could cut across loop B since they are confined to the low resistant iron path and the loop B is outside this path. It it true, nevertheless, that the lines do cut across this loop so we must investigate how this seeming paradox can exist. There are various ways in which this may be explained but for our purpose we shall refer to it as in Fig. 56.

As the magnetizing force acts in one direction and then in the other the small magnetized particles, of which the iron is made up, turn in one direction and then in the other. Fig. 56 (a) shows the positions of the various particles for a given direction of the magnetizing force. Fig. 56 (b) shows the positions for the opposite direction of the magnetizing force. Between these two positions are many others one of which is shown in Fig. 56 (c). When in position (a) the lines of force spreading out from the ends of the magnetized particles emerge from one end of the piece and enter at the other; in (b) the opposite of this obtains; while in (c) the result is intermediate between the two. Fig. 56 (d) shows various positions of one particle and the consequent direction of flow of the magnetic lines emanating from it. Now if this piece of material be encircled by a loop such as B, Fig. 55 (d) the lines will cut across it as the particles reverse under the influence of the magnetizing force thereby generating a voltage in it as previously explained.

Loop A Fig. 55 is the one which creates the magnetic flow due to the fact that it is excited by means of the generator that is connected in its circuit. For this reason it is given the name *primary* and is spoken of as the primary of the transformer. Loop B has a voltage induced in it as a result of the action of the primary A and, therefore depends on, or is secondary to, loop A. It is, for this reason, termed the *secondary* of the transfomer. The primary and the secondary are shown, in Fig. 55, as being composed of a single turn but, in practice, both are made up of a number of turns. The reason for this may be best explained by consideration of the following: It is only possible to magnetize a piece of iron to a certain point called the saturation point so that the amount of power it is possible to transform with a given weight

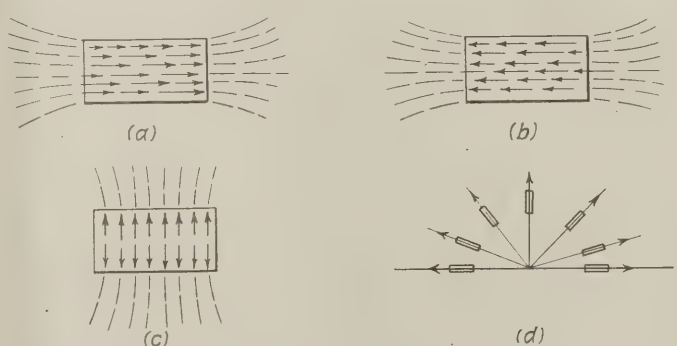


Fig. 56

of iron is limited. Again, the degree of magnetization of the iron depends on the magnetizing force which is expressed in ampere-turns so that one ampere flowing through a thousand turns produces the same magnetizing force as one thousand amperes flowing through one turn. Therefore, if the transformer is situated at some distance from the point at which the current is generated it will be readily seen that it is more economical to transmit one ampere of current to the transformer than one thousand because the difference in the weight of conductor is enormous. This ties in with the fact that alternating current

is, in ordinary cases, generated at a more or less high voltage; the standard voltages being 110, 220, 440, 660, 1,100, 2,200 and so on up to a maximum which, at the present time, is 220,000 for transmission purposes. Therefore we shall think of the transformer loops or coils, hereafter, as being composed of many turns as in Fig. 57.

Fig. 57 (a) shows a transformer, the primary of which consists of 100 turns and the secondary 50 turns. The primary, it will be noted, is connected to generator *G* while the secondary is open-circuited—that is, the two ends of the winding are not connected together. If the generator is operated a current will flow through the primary circuit and a flux will flow though the iron. The reversing of the flux will cause the lines to cut across the turns of the primary as well as those of the secondary so that a counter voltage will manifest itself in the primary winding at the same time that a voltage is generated in the secondary winding. Since the secondary is open-circuited the voltage will not be effective in causing a current to flow through its turns. The effect of the counter voltage in the primary winding is to limit the voltage so that only sufficient current will flow necessary to magnetize the iron to the degree determined by the designer of the transformer. The manner in which this is brought about is best explained by means of an illustration. Thus if the primary voltage is 110 and the resistance of the winding is one ohm, then if it were not for this superself inductance or counter voltage the current through the winding would be 110 amperes. However, the counter voltage amounts to 109 volts so that only one volt is effective in forcing current through the winding, the result being that one ampere flows in the circuit. This

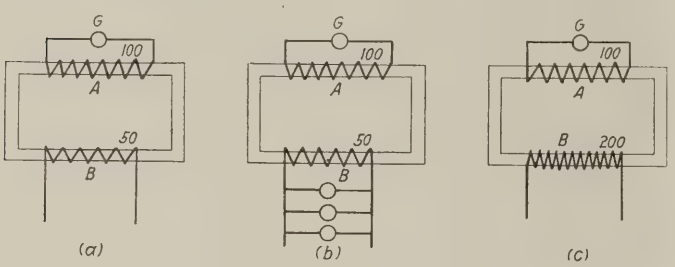


Fig. 57

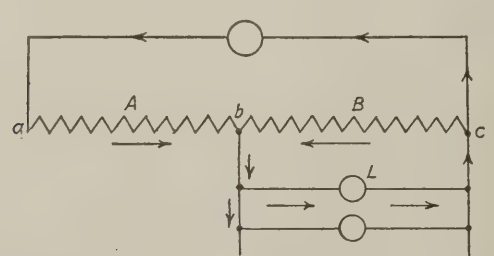


Fig. 58

is called the magnetizing current of the transformer and will continue to flow as long as the generator is operating. It will be noted that the counter voltage was 109, one volt being lost in overcoming the resistance of the circuit. Now since the number of turns in the secondary coil is only half that in the primary coil it is readily seen that the voltage generated in this secondary coil will be only half that generated in the primary so that in this case the secondary voltage will be about 55 volts. Should the reason not be clearly understood for the secondary voltage being less than the primary in this case, it is only necessary to recall that in the case of a simple direct-current generator, the voltage generated, for a given strength of magnetic flux, and speed of rotation, depends on the number of turns on the armature. The same reasoning applies to this case because the flux (effective value) is constant, the speed of cutting (60 cycles or 120 alterna-

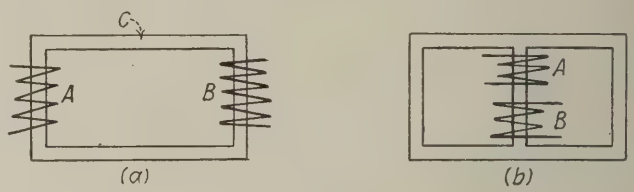


Fig. 59

tions per second) is constant so that the voltage generated in the two coils will depend on the relative number of turns, which in this case is 100 to 50 or 2 to 1, so that the relative voltages are in the ratio of 2 to 1 or 109 volts to 55 volts. If a load be connected to the secondary winding as at *L*, Fig. 57 (b), the condition of the whole transformer will quickly change as will be seen from a consideration of the following. As the secondary circuit is completed (closed) by means of the load, a current will flow through its windings and this current will be in such direction as to oppose the magnetizing force of the primary winding, as we learned in connection with the study of self-induction. This will result in a decrease in the effective magnetizing force which will result in a decrease in flux. The instant that the flux begins to decrease, the counter voltage of the primary winding will decrease, thereby causing the effective voltage to become greater.

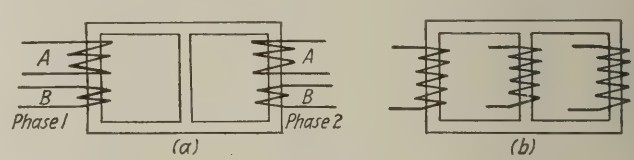


Fig. 60

Thus if the counter voltage decreases to 108 the effective voltage becomes 110 minus 108 or two volts, so that the current will increase with a consequent increase of the magnetizing force and flux. In any case the current in the primary will increase to the point where the primary magnetizing force is equal to that of the secondary plus the force necessary to maintain the magnetization of the circuit. If the load on the secondary be decreased the current through it will decrease; its magnetizing, or rather counter magnetizing force will decrease and the flux through the circuit will tend to increase. This will result in a higher primary counter voltage which will, in turn, result in decreased primary current so that we see the magnetization of the circuit is maintained constant for any and all conditions of load. It should be noted in this particular case, that the current through the secondary must be twice the value of that in the primary to produce the same magnetizing force because it has only half as many turns as the primary. Thus if the secondary current is two amperes, its opposing force will be one-hundred ampere turns. The increase in primary current necessary to overcome this, in order to maintain the magnetization

of the circuit, will be only one ampere. This one ampere will provide on hundred ampere-turns of force since there are one hundred turns in the primary. Thus if the transformer is rated at 11 kilowatts (11,000 watts) and the voltage of the primary is 110 then the primary current at full-load will be 100 amperes. If the secondary voltage is 55 the full-load secondary current will be 200 amperes. It should be noted that the power is, in both cases (primary and secondary), the same—viz., 110 times 100 and

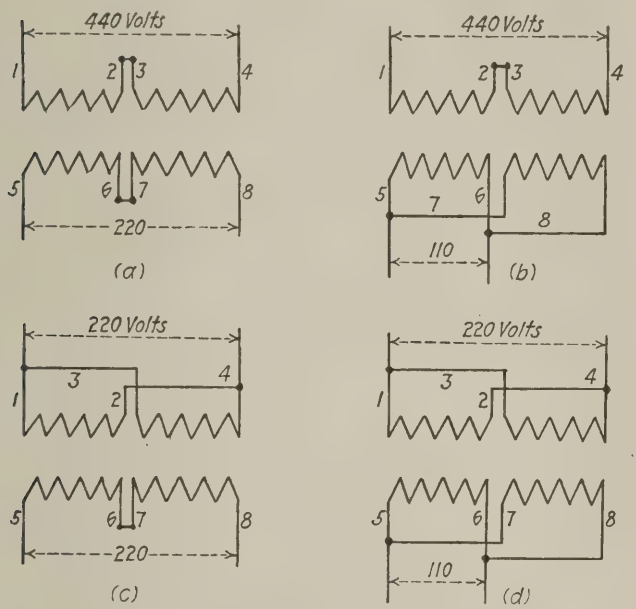


Fig. 61

55 times 200. The transformer we have discussed is termed a step-down transformer because of the fact that it lowers or steps-down the voltage from a high to a lower value; in this case 110 to 55. It is possible, however, to step the voltage up from a low to a higher value. This is accomplished in the step-up transformer which is illustrated in Fig. 57 (c). Here it is seen that the primary is composed of fewer turns than the secondary so that the secondary voltage is higher than the counter voltage of the primary. We shall investigate this in the same man-

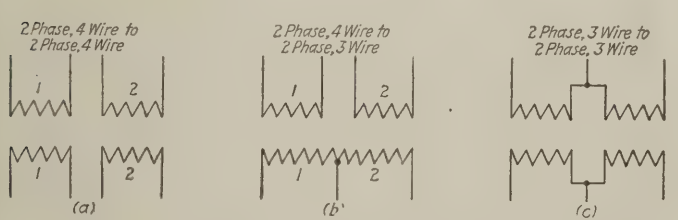


Fig. 62

ner as we did the step-down transformer. If the primary voltage is 110 and its number of turns 100, while the number of turns of the secondary is 200, then the counter voltage of the primary will be as before, 109 or thereabouts, while the voltage induced in the secondary will be about twice this or 218 volts. If the secondary circuit be closed through a suitable load, say one ampere, then its opposing force will become 200 ampere-turns and the increase in primary current necessary to overcome this force will be two amperes because there are only half as many turns in the primary as in the secondary.

The type of transformer we have discussed thus far is the one most generally used and is known as the insulated type of power transformer, insulated because the primary and secondary are separated or insulated from each other. There are other special types of transformers that we shall become acquainted with later on but there is a special type of power transformer, called the auto-transformer, that we should obtain a knowledge of before passing to the next section.

Fig. 58 shows generator *G* connected to a transforming device *A-B*, the generator being connected across the two ends *a* and *c* while the load is connected across terminals *b* and *c* of section *B*. If the voltage of the generator is 220 and that necessary for the load is 110 then if the number of turns in section *A* is the same as that in section *B* the voltage across the load will be 110 as desired. The action of this transformer is as follows: Current from *G* flows through section *A* to *b* and thence through the load to *c*. This current magnetizes the iron, thereby inducing a voltage in section *B* which acts in such a direction as to oppose the magnetization of *A*. Since the load is connected across it, it forces a current through the load in the same direction as the primary current so that the two currents add up to make up the total current flowing through the load and each will supply half the total current in this case. If it were desired to have a load voltage of 55 it would be only necessary that the number of turns

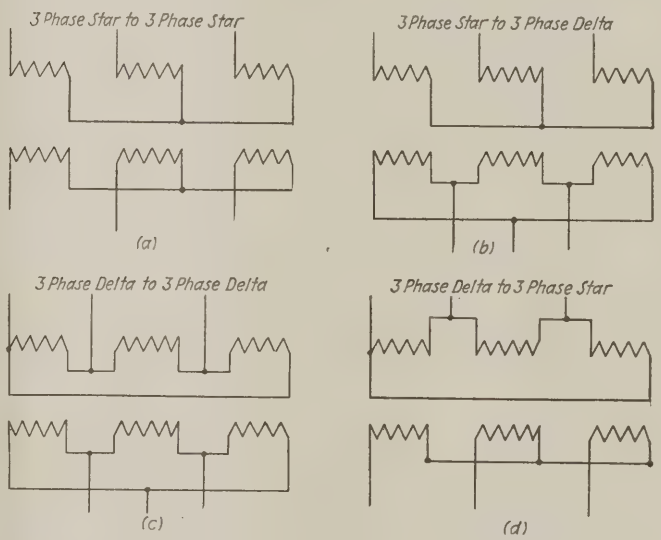


Fig. 63

in the two sections be so proportioned that the load would be connected across one-fourth of the total number of turns. Thus if the total turns is 200 then section *A* would be 150 turns and section *B*, 50 turns. In this case only one-fourth of the current would be supplied by the generator, the other three-fourths being supplied by section *B*. The theory of the action of the auto-transformer is practically the same as that for the insulated transformer with slight modification. At no load, i.e., when the load is not connected, the magnetizing current flows through both sections in the same direction but when the load is connected the primary current takes the easier path at *b* and the voltage of section *B*, which had been part of the primary counter voltage before the load was connected, becomes effective in forcing current through the load, as previously mentioned. The reason that the current supplied to the load of each section varies according to or rather inversely as the number of turns in the section is the same as in the

case of the insulated transformer—the opposing force of the primary necessary to overcome that of the secondary, varies with the opposing force, in ampere-turns, of the secondary. Thus if the secondary consists of 50 turns and the primary 150 turns, then only one-third of the amount of current in the secondary will need to flow through the primary to produce the proper opposing force. In this particular case the current through the primary circuit, section A will be one-third of that flowing through the secondary section B so that one part of the current will be supplied by the primary and three parts by the secondary; the total being four parts, one fourth of this total being primary and three-fourths secondary. Here we see that the current is inversely as the number of turns in the section for B has one-third as many turns as A and, therefore supplies $\frac{1}{\frac{1}{3}}$ — or three times as much current as A. It will be noted, however, that generator G supplies all the power of the circuit.

The no-load power-factor of a transformer is almost zero because the magnetizing current is almost 90 degrees behind the voltage. This is true because of the fact that the load (primary of the transformer) is a purely inductive circuit, the effect of resistance being negligible at the low value of current.

The regulation of a transformer is the per cent rise in voltage of the transformer as the load is suddenly changed from full-load to no-load and this value is useful in determining the type of transformer best suited to a given type or class of load. Thus a transformer that is entirely suited to some classes of power loads where voltage variation is not important, would be totally unfitted to a lighting load where voltage variation is of primary importance.

The efficacy of the transformer as regards saving in the transmission of power may be illustrated by means of an example. Thus if we desire to supply a load requiring 100 amperes at 100 volts and said load is a mile from the power house we may generate the voltage at 100 and transmit it directly without the use of a transformer, and we shall use a No. 1 wire for each of the two lines. However, we could generate the power at 800 volts and transmit it over two No. 10 wires for the same per cent loss, the required weight of copper being one-eighth. We could also generate the power at 100 volts; step it up to 800

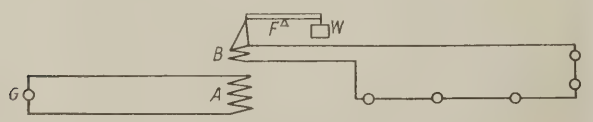


Fig. 64

volts near the generator and step it down again to 100 at the other end of the line.

Having considered the theoretical side of transformers we may now look into their construction. As to general construction there are two types of transformers, namely, core and shell.

Fig. 59 (a) illustrates the core type. It is seen that the coils surround a leg or core, hence the name. Fig. 59 (b) illustrates the shell type. It may be seen that the coil is almost entirely surrounded by a shell of iron, the only exposed parts being the ends of the coil, whereas no part was entirely enclosed in the core type.

Transformers may be still further classed as single and polyphase. We have considered the single-phase transformer in detail and it may be stated that there is absolutely no difference between it and the polyphase; the polyphase being, in effect, a group of three single-phase transformers in the same container. Fig 60 (a) shows a two-phase transformer, the center leg of the core being somewhat larger than the two outer ones in order that it may carry the combined flux of the outer two. Fig. 60 (b) shows a three-phase transformer having one coil on each of the three legs. The flow of flux through the core follows the same laws as the flow of current through a polyphase circuit, which will explain why the center leg of the two-phase transformer need only be 1.414 times the area of the

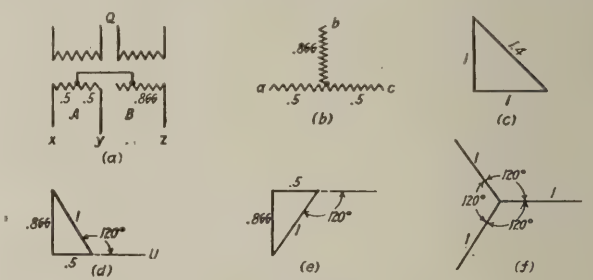


Fig. 65

outer two, and also why three legs of the same size carry the flux of the three-phase transformer.

Transformers are also classed in regard to the method of cooling, as air cooled, oil cooled, and water cooled. The air cooled transformer has the coils directly exposed to the air or has a sheet iron casing around it through which air is forced under pressure. The oil cooled transformer is surrounded by an iron case which is filled with oil. The oil conducts the heat from the coils to the case where it is radiated to the air. The water cooled type is a form of oil cooled transformer which has a set of cooling pipes passing through the oil. Water, circulating through these pipes, absorbs the heat from the oil and carries it to a suitable heat radiator where the water gives up its heat before being again forced through the pipes by the pump.

The coils of most transformers are divided into two sections the terminals of which are brought out to suitable terminal blocks. Fig. 61 shows various voltage combinations that it is possible to obtain by connecting these sections in various ways. The conventional method of transformer representation is followed in this and following diagrams.

Two-phase connections are shows in Fig. 62.

Three-phase connections are shown in Fig. 63.

For polyphase transformation either polyphase transformers or separate, properly grouped, single phase transformers may be used. Thus two transformers would be necessary for two-phase and three for three-phase.

There is one other type of transformer that is somewhat less used than it was a few years ago and that is the constant current transformer. It was once extensively used for street lighting where the arc lamp was used for this purpose. These lamps were connected in series with each other and with the secondary of the constant current transformer as shown in Fig. 64.

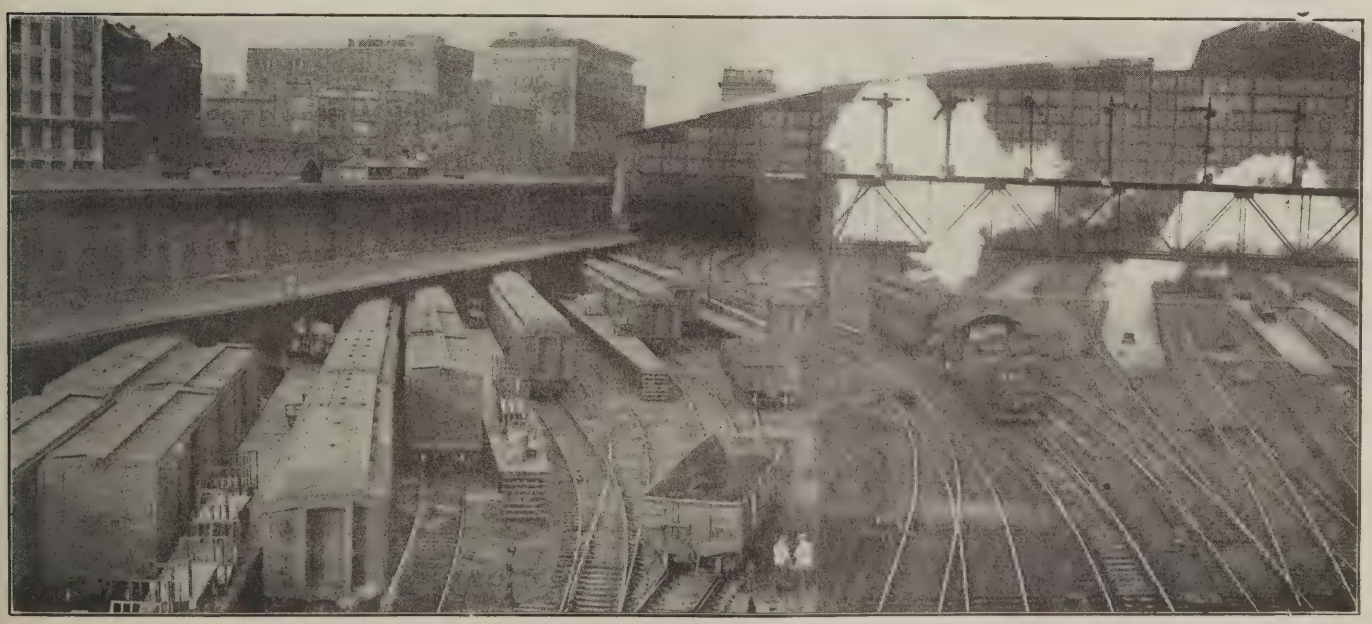
The primary of the transformer is stationary and is connected to the generator G. The secondary coil moves up or down, being counter-balanced by weight W which operates at the other end of lever F from which the coil is

suspended. Coil B is slightly heavier than weight W so that it normally tends to rest on A. With G generating and no load connected to B, B rests on A but when the load is connected the two coils oppose one another because of the fact that their adjacent poles are alike and like poles repel. Coil B will be repelled until it reaches such a point that a balance is obtained between the repulsion and the excess of weight of B over that of W. If the load is decreased by cutting one of the lamps out of circuit the current in B will increase momentarily and it will be repelled further until a balance is again obtained. If more lamps are added the current will decrease and the coils will come closer together. The closer they come together the more voltage is induced in B so that the current in the circuit is maintained constant even though the load has been increased. When the load was decreased it was necessary that the voltage in the circuit be lowered. This was accomplished, as we have seen, by the coils moving farther apart due to the momentary rush of additional current. Thus it is seen that the constant current transformer automatically maintains constant current in the circuit for any load within range of its capacity.

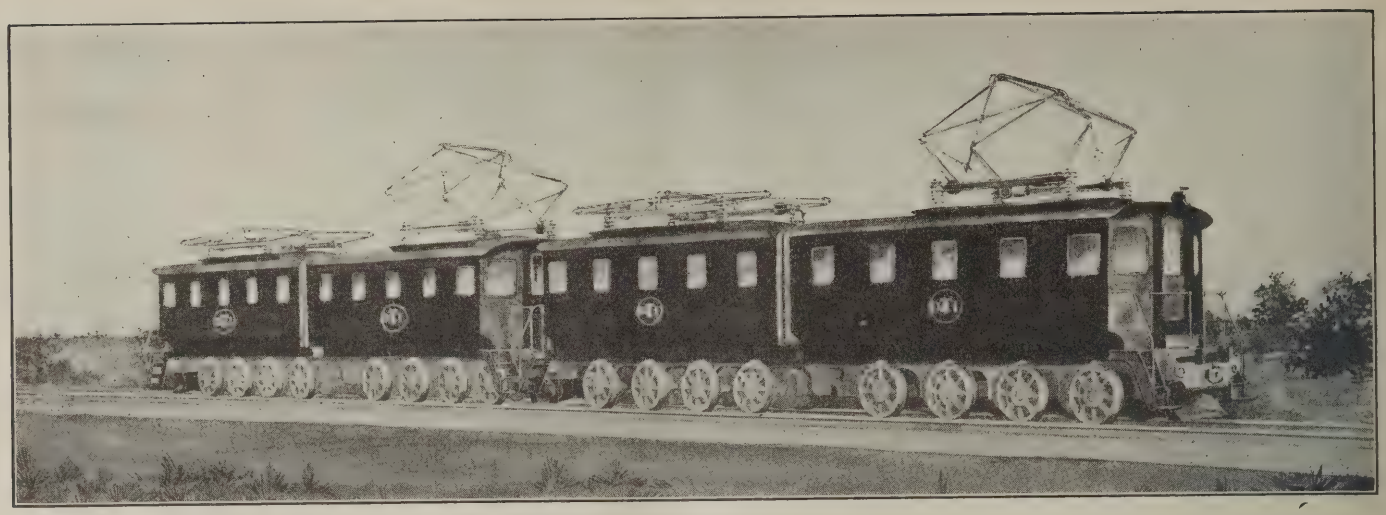
There is one other method of transformation that must be considered before passing from the subject. Thus far we have considered the subject of voltage transformation, but our investigation would not be complete without mention of phase transformation. By this method two-phase current is changed to three-phase or vice versa. There are a few methods of doing this, all of which work on the same principle. The more common method is known as the Scott system.

Fig. 65 shows the Scott system of transformation and the process of this transformation. Fig. 65 (a) shows the method of changing two-phase current to three-phase. The primaries which are identical are shown at Q and are supplied with two-phase current. The secondaries shown at T are specially wound so that a tap is brought out from the center of one of them as at A, while the second has in use, only .866 of the number of turns of the first as at B. One end of this winding is seen to connect to the center tap of A. When two-phase current is fed to the primary, three-phase current is obtained from wires X, Y and Z. How this is accomplished will now be made clear. Fig. 65 (b) shows, somewhat more clearly, the connection of the two secondaries, the voltages induced in them being 90 degrees apart as in Fig. 65 (c). The voltage a—c is represented in direction by U Fig. 65 (d) while that between b and c is obtained by combining the .866 voltage with half that of the voltage of A. By completing the triangle it is found that this voltage is equal to that of A and displaced 120 degrees from it. The voltage between b and a is obtained as in Fig. 65 (e) by combining the .866 voltage with the other half of that of A. This voltage is found to be equal to that of A and displaced 120 degrees from it and from that between the other two wires, thus proving that the current we have obtained is three-phase while that of the primary is two-phase. By supplying three-phase current to wires X, Y, and Z, we could take two-phase current from the other side of the transformer, the reasoning being the reverse of that which we have just been considering.

Probably more electrical business could be done in Canada than is being obtained there today if more intensive sales efforts were made by American manufacturers. Many business men apparently make their sales appeal in that market only through advertising or through correspondence, and seldom get the advantage that results from personal contact with the buyer. Canada is so close to home that more consideration could advantageously be given to this point. Few manufacturers have analyzed Canadian possibilities as closely as they have those of countries that are really foreign to us, and do not realize the magnitude of our electrical exports to Canada. A study of statistics for a period of years shows that there has been a well maintained growth in the shipments of electrical products to the Canadian market.



South Station, Boston



How One of the Detroit & Ironton Locomotives Will Look When Completed

Electric Locomotives for the Detroit & Ironton

Direct Current Driving Motors Will Receive Power from 22,000-Volt Alternating Current Trolley

By Fred Allison, H. L. Maher and L. J. Hibbard
Ford Motor Company and Westinghouse Electric & Manufacturing Co.

AN important development in the electrification of steam railroads is that recently announced for the Detroit & Ironton Railroad. As usual, Mr. Ford has not been restricted by past practice or tendencies in the choice of electrical system and of type of motive power units for his road.

The result has been the adoption of a trolley voltage of 22,000 volts, 25 cycles, alternating current, a trolley voltage twice as high as any previously used in this country. Also a type of motive power unit that is not only novel in electrical design, but embodies many new and important ideas in the mechanical design, has been adopted for this installation.

The mechanical parts for the new locomotives are being designed and built by the Ford Motor Company while the electrical equipment is being designed and built to Ford Motor Company specifications by the Westinghouse Electric & Manufacturing Company. The initial order calls for a locomotive comprising two motive power units operated in multiple.

The locomotive will develop a maximum of 5,000 hp. at 17 m.p.h. and will exert a maximum starting tractive force of 225,000 lb. on the basis of a 42,500 lb. axle loading with 33 1/3 per cent adhesion. The nominal rating of the locomotive will be 4,200 hp. It will also deliver 3,600 hp. continually at all speeds between 17 m.p.h. and 25 m.p.h. and will exert 54,000 lb. tractive force continuously when operating at 25 m.p.h.

Each motive power unit will be arranged for double-end operation so that an operating locomotive may consist of either one, two or more units as desired. It is estimated that each motive power unit will weight 170 tons. All weight will be carried on the driving wheels.

The motive power unit selected for this electrification is of the motor-generator type. The principal reasons which have led to the adoption of this type can be summarized as follows:

1. Use of alternating current power supply for the trolley.

2. Direct current traction motors of the most rugged type due to the opportunity to design the motor for its own best condition, regardless of voltages, line surges, etc. In other words, the motors have the most rugged electrical characteristics and maximum space and weight efficiency that can be secured.

3. Possibilities for the simplification of the mechanical parts due to the high space and weight efficiency obtained in the traction motors.

4. Simplicity and flexibility of control.

5. Simplicity and regenerative system and ability to regenerate at any speed from the maximum to practically standstill.

6. Voltage control with consequent freedom from rheostatic losses, low accelerating peak loads, and ability to operate continuously at any desired speed.

7. Speed characteristics and ability of locomotive to adapt itself to all changes in the profile.

8. Constant horsepower characteristic enabling the locomotive to develop its full capacity under a variety of speed and tractive effort conditions.

9. Inherent voltage regulating effect of driving motor of locomotive motor-generator set with its attendant favorable effect on the distribution system.

10. Little tendency for driver wheels to start or continue slipping during accelerating periods because the voltage impressed across each traction motor, while the maximum starting tractive effort is being exerted, is low and does not increase if slipping starts.

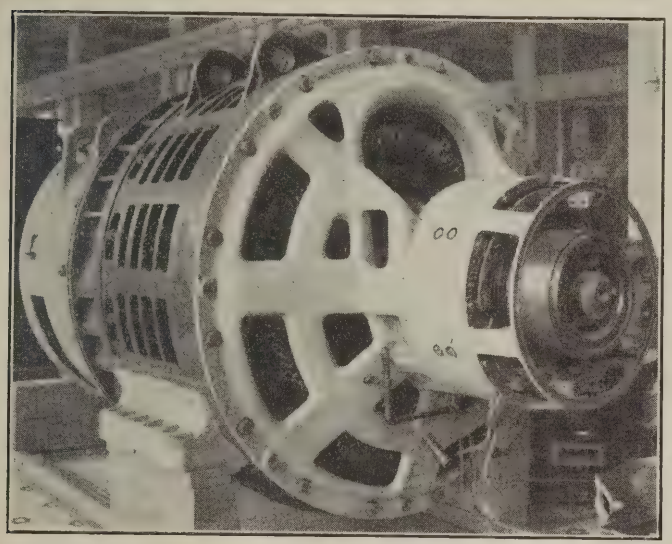
11. Ability to maintain the a-c. power drawn by the

locomotive at unity power factor and consequent tendency to low transmission losses.

12. Ability to operate at full load in the same train with any other type of alternating current locomotive.

13. Ability to operate as a constant speed type of locomotive on all applications where this feature is desirable by separately exciting the traction motors throughout the motoring period.

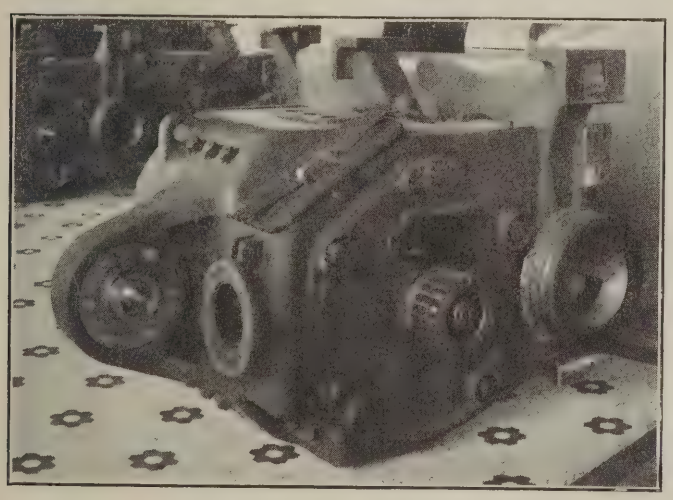
14. Large number of constant running speeds obtainable when motoring on separately excited connections.



One of the Motor Generator Sets Consisting of a 1,500 Kw. 750 r.p.m. Direct Current Generator and Separate Exciter Driven by a 2,100 H.P. Alternating Current Motor

15. Adaptability to locomotive designs with all weight on drivers.

In short, this type of engine was adopted because it is believed that it will furnish a most flexible and reliable means of utilizing the power which will be delivered to it



One of the Traction Motors

by the flexible high voltage alternating current trolley system.

Each motive power unit will be equipped with a transformer, a direct-current generator driven by a single-phase motor, eight axle-hung direct-current, series type traction motors, and suitable control and auxiliary apparatus. Single-phase alternating-current power at 22,000 volts will be collected from the overhead system by means of a pantagraph and conducted through an oil circuit-breaker to the primary side of the transformer, where it will be stepped down to a suitable voltage for driving the motor-generator set. Direct-current power, which can be regulated from zero to 600 volts, will be delivered by the motor-generator set to the traction motors, connected permanently in parallel. The locomotive is designed for regenerative braking.

The locomotive transformer will be 2,000 kva., two-circuit, oil-insulated, air-cooled railway type unit. The primary winding may be connected to receive either 22,000 or 11,000-volt power. The secondary will deliver current at 1,250 volts.

The high voltage side of the transformer will be connected between the circuit-breaker and ground to series with two single-pole, double-throw knife switches in such a way that the transformer can be connected to operate on either 22,000 or 11,000 volts as desired by throwing the switches to the proper position. This feature has been included so that these locomotives can be operated over connecting 11,000-volt lines if desired at some future date.

The locomotive motor-generator set will consist of a 2,100-hp., 25-cycle, four-pole, single-phase motor, driving a 1,500-kw., 600-volt, 2,500-ampere generator at 750 r.p.m. The set will be a self-contained machine supported at three points and will comprise two bearing brackets

Two of the Four Cabs for One of the Locomotives.

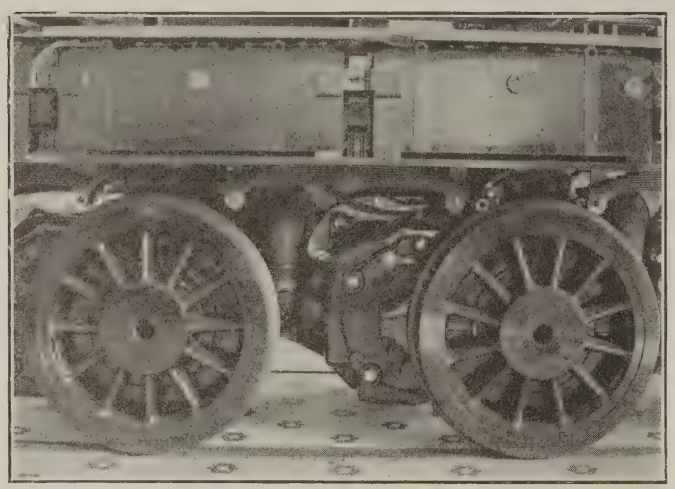
with suitable bearings, motor stator, a generator field, and a shaft carrying the generator armature and the motor rotor. A 75-kw. 125-volt, direct-current "main exciter" will be mounted directly upon a shaft extension at the motor end of the set, while a 25 kw. direct-current "regenerative exciter" will be mounted directly upon a shaft extension at the other end.

The generator will be provided with series excited differential field, interpole field and compensating field as well as a separately excited field. The 75 kw. main exciter will be used to supply excitation to the motor field, the generator field, regenerative exciter field, and to supply power for all auxiliary motors, and for the control circuits. The 25 kw. regenerative exciter will be used to separately excite the traction motor fields during the regenerative period and during high speed motoring periods.

The locomotive traction motors will be 225-hp., 600-volt, direct-current series, axle-hung machines. Each motor will be flexibly connected to the driving axle by double gearing, that is, a gear at each side. A 22-tooth, 3½ in. face, 3 dp., pinion, suitable for meshing with a corresponding 98-tooth gear will be mounted on a shaft

extension at each end of the motor. The motors will be of a special mechanical construction for application to the mechanical parts being designed and built by Mr. Ford.

Each motive power unit will be equipped with double-end control. Forty-five normal running speeds will be available between standstill and maximum speed during both the motoring and regenerating periods. The locomotive speed during both the motoring and regenerating



A Portion of the Running Gear Showing Driving Wheels, Hollow Axles, Motors and Cooling Air Duct. One End of Each Motor Is Supported on the Axle and the Other by a Lug Which Projects Down From and Which Is a Part of the Locomotive Frame Casting

periods will be manually controlled from standstill to seventeen miles per hour by regulating the main generator voltage and from 17 m.p.h. to the maximum speed by regulating the main field strength of the traction motors.

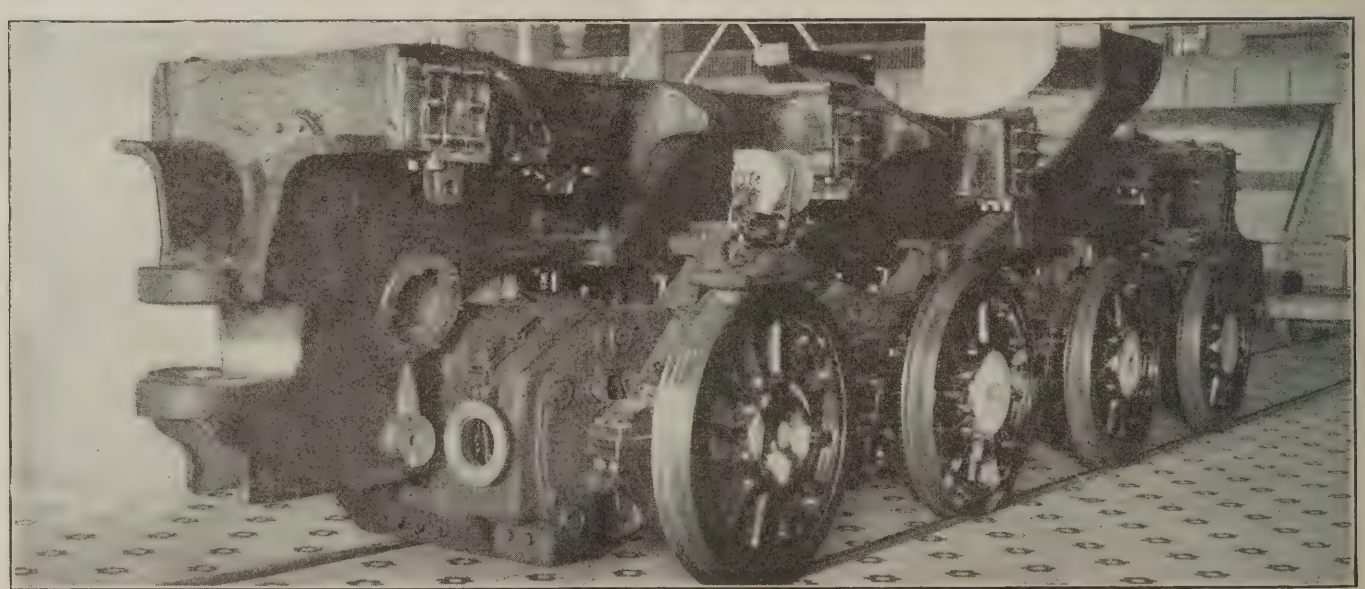
The traction motors will be connected as series excited motors during the motoring period from standstill to 17 m.p.h. and as separately excited motors during the motoring period from 17 m.p.h. to maximum speed. The traction motor fields are separately excited throughout the entire regenerative period.

Regeneration may be obtained at any time while the traction motors are separately excited by regulating the generator voltage and traction motor field strength so that the motor voltage overbalances the generator voltage and causes the armature current to reverse. This will cause the traction motors to act as generators, driving the main generator as a motor which in turn drives the a-c. motor, causing it to become a generator and return power to the line.

A closed circuit type of transition will be utilized in going from the series excited to the separately excited connections of the traction motors, and when desired the same type of transition may be used to change back to the series excited from the separately excited connections. Thus the separately excited connections may be completed while the traction motors are energized and working at full load, as series excited motors, without interrupting or appreciably changing the value of motoring tractive effort either during the changeover period or after the separately excited connections have been completed.

The closed circuit transitions can be utilized advantageously during the motoring period to change from the series connections to the traction motor fields to the separately excited connection when it is desired to increase the speed of the locomotive by weakening the field strength of the traction motors. It can also be used to complete the separately excited connections as the locomotive is motoring up to and going over the top of a grade so that the engine will automatically start to regenerate as the speed of the train begins to increase on the down grade.

Since the single-phase driving motor of the main motor-generator set, like the phase converter of the single phase three phase locomotive, is not self-starting, the set will be started and partially accelerated up to speed from the d-c. end. A 60-cell, 125-volt storage battery will be provided on each unit for this purpose. This battery will be used further for energizing the control circuits and supplying power to the compressor motor whenever the motor-generator set is shut down. The motor-generator set will be accelerated to approximately 50 per cent speed by means of the main generator and from 50 per cent speed to full speed by means of the a-c. motor. Starting



One of the Two Running Gear Sections Which Carry the Motor-Generator Units Showing Cradle for Supporting the Unit. Air Brakes Like the One Shown on the Wheel in the Foreground Are Provided for Six Wheels on Each of the Four Sections

from rest with a full tonnage train the traction motors will be energized as series excited motors and the train may be accelerated up to a continuous full tractive effort running speed of approximately seventeen miles per hour by manually regulating the main generator voltage by means of the external field resistor and a set of 50-ampere, 125-volt switches.

If desired and the load and grade conditions are such as to permit the use of a higher running speed than is obtainable with the series connections, a closed circuit transition will be made from the series connection to the separately excited connection of the traction motors. The speed may then be increased by weakening the field strength of the traction motors. This will be accomplished by manually regulating the regenerative exciter voltage through an external field resistor and a set of 5-ampere 125-volt switches.

Then when the train passes over the crest of a hill and it is desired to maintain some constant speed while descending the grade, the traction motors will be made to act as generators by strengthening and properly regulating their fields.

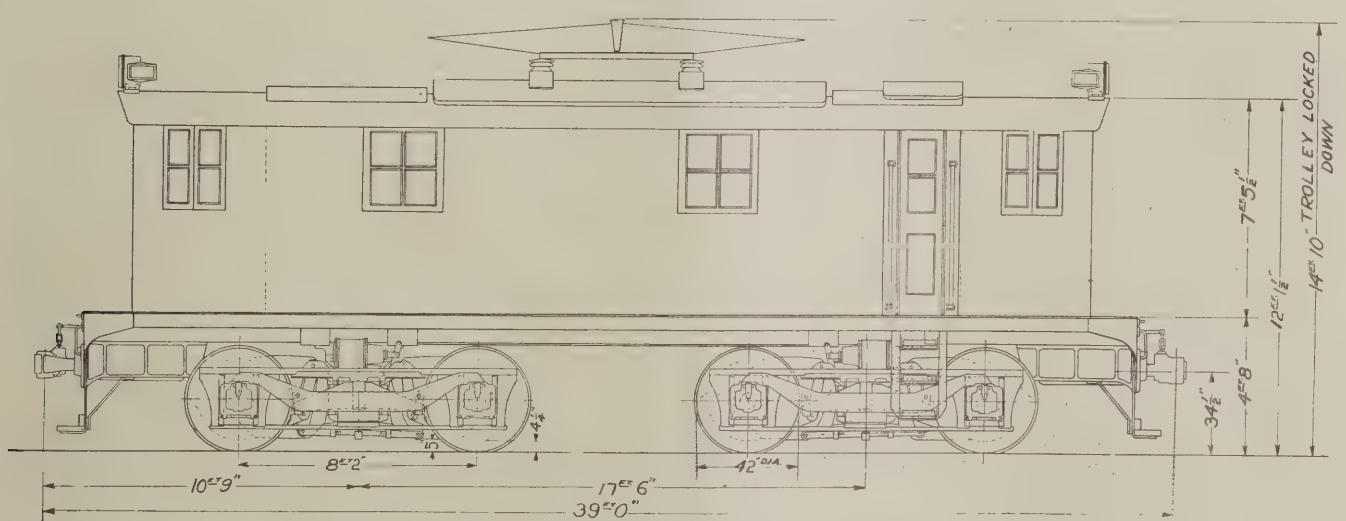
When the train is to be brought to rest heavier regenerative braking may be utilized if desired in bringing the train to a very low speed before applying the air brake.

The speed may be decreased to approximately seventeen miles per hour by properly regulating the traction motor field strength while the speed may be decreased below seventeen miles per hour by regulating the generator voltage.

Motor-Generator Locomotives for the New Haven

Alternating Current from Trolley Converted to Direct Current for Motors on the Locomotives

THE New York, New Haven & Hartford has ordered from the General Electric Company, and the American Locomotive Company seven single phase locomotives of a new type. Five of these units are for freight service and will be used on the main line between Oak Point and New Haven. The other two are switching locomotives and will be used in general yard service. Whenever double heading, these locomotives will function in multiple unit with the present single phase locomotives.



Side Elevation of One of the Two Motor-Generator Type Switching Locomotives

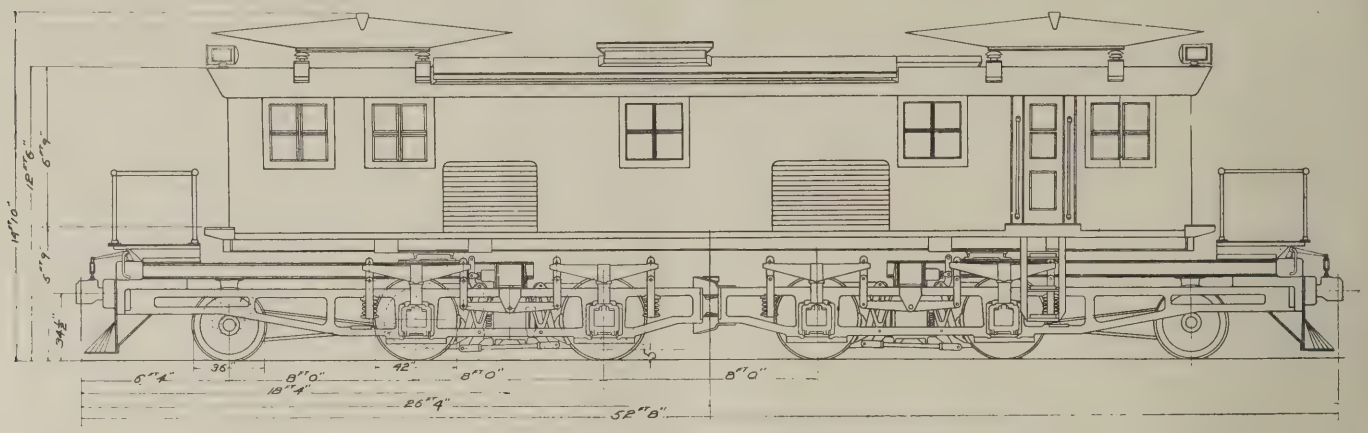
The design of this type of locomotive is unusual in that although it is actuated from a single phase trolley it does not have alternating current traction motors. Each locomotive, in fact, contains a traveling substation and will be equipped with a synchronous motor-generator set for converting the 11,000-volt 25-cycle single phase supply to direct current, and with direct current railway motors driving the axles.

Power is collected by the usual slider pantagraph trolley and is delivered to a main transformer situated in the locomotive cab. This main transformer steps down the trolley potential to 2,300 volts, which drives a single phase synchronous motor direct connected to the main generator. The main generator which delivers current to the traction motors is designed with a variable field, and the speed of the locomotive is regulated by field control of this generator. The traction motors are of the standard series direct current railway type, the performance of which is well known. They are geared to the axle through cushion type gears which allow a small movement of the gear ring about the gear hub or center, thus minimizing shocks and stresses in the gears and pinions.

Protective devices have been studied with great care. Between the pantagraph trolley and the main transformer a time limit automatic oil circuit breaker is installed. Between the direct current generator and the motors are a high speed circuit breaker and line switches. The high speed circuit breaker will afford protection to both the motors and the generators and will ordinarily prevent the opening of the time limit switch or of the trolley or feeder sectionalizing switches, and will thus prevent any inter-

ference with the continuous operation of the motor-generator set.

The system of control, by varying the field strength of the generator used, in connection with the characteristics of the motor-generator set, gives a locomotive which is extremely flexible and adaptable to all operating conditions. It also has the very desirable characteristic of operating at a power factor of unity or better under all ranges of load. The set has been made of sufficient capacity to take care of the rated loads and will also furnish and appreciable amount of wattless current, especially at light loads for power factor correction. This tends to improve the trolley voltage for all load conditions, and should be of material benefit in the operation of the entire system.



Side Elevation of One of the Five Motor-Generator Type Freight Locomotives

Missouri Pacific Experiments with Train Radio

Agricultural Progress Train in Rural Districts Receives Programs from Fifty Stations

By Ray E. Krueger

DURING the early part of this year the Missouri Pacific Railroad sent Agricultural Progress trains over its lines for the purpose of acquainting its rural patrons with latest methods in agriculture.

The trains created great interest among the farmers and others in the territory through which they passed, and one of the features which attracted most attention was their radio receiving equipment and the programs which were received.

The following account of the experiences with radio equipment may be of some assistance to others who contemplate train installations of radio equipment.

The first train was started from Little Rock, Ark., where the cars were equipped, and traversed the states of Arkansas, Missouri and Oklahoma. The train consisted of three cars, a lecture car, an exhibit car and a business car.

The lecture car was equipped with a motion picture machine and the radio receiver, which was used to entertain the patrons during their visit to the show and exhibit car.

Much interest was shown by the people, and many interesting stories were told by people who visited the radio exhibit. In one instance, a family rode twenty-five miles in a wagon to see the train and hear the radio. Many others also stated they had never heard or seen a radio outfit before. One elderly couple admitted it had been more than twenty years since they had been in town.

The Antenna System

One antenna was mounted on the roof of the lecture car (one wire on each side) and one antenna on the exhibit car. These antennae were connected by jumpers between the two cars, making an approximate total length of 100 feet.

The wires were No. 8 copper and were supported by half-inch pipe. The method of mounting the pipe and insulators is shown in Fig. 1. Wooden plugs were driven into the ends of the pipe and the insulators were fastened to the pipe with screws. Of course, if transmission was to be handled from the train, better and higher potential insulation would have been required.

The lead-in wires were brought through the ventilators at the rear of the lecture car and connected to the receiving set which was mounted on a platform erected in the rear of the car. The center of the car would have been the best location for the receiving set as it would have helped to eliminate some of the jarring that prevailed when the set was over the trucks, but, on account of the motion picture machine being located in the car, it was necessary to install the receiver in the rear of the car. This antenna was quite efficient considering its height was only twelve feet above the rails. A wire about fifty feet long was strung about the inside of the car and also used as an antenna, and while the reception and volume were good they did not compare with the results obtained with the outside antenna.

The Ground System

The outfit was grounded with No. 8 wire to a brace rod beneath the car which is bolted to the trucks. In this way the rails served as a ground. This method of grounding is not very efficient, but is the best that can be done under moving conditions when the outfit being used necessitates the use of an antenna and ground.

The Receiver

The receiver was a five tube Freed-Eisemann "neutrodyne" receiver and used in connection with a two stage Western Electric power amplifier.

The receiver used 301-A tubes throughout, 45 volts

Part of the Antenna System

on the detector plate and 90 volts on the plates of the radio and audio frequency stages. Three 216-A tubes were used in power amplifier with 180 volts on the plate. Separate "A" and "B" batteries were used on the receiver and amplifier.

Reception While Standing Still

More than fifty of the best stations in the United States were logged and heard on the loud speaker during the trip. This does not mean that only fifty programs were received, but it does mean that they were logged. A station once logged can be easily picked up again at will, if that particular station is on the air. Some nights, as many as sixteen stations furnished parts of the program. CYL—Mexico City, and PWX—Havana, Cuba, were heard on the loud speaker on several occasions.

Results While Moving

Reception while moving was hampered by the vibration of the elements of the tubes in the receiver. Several methods of eliminating this were tried (such as putting soft rubber pads and a spring under the outfit), but these methods did not relieve the situation a great deal.

Stations KDKA, KHJ, WOC, WHB, WDAP, WMC and several others were received while train was moving at top speed.

Hardly any change in volume was noticed while moving except when going through tunnels, over steel bridges, or passing near high embankments. The three above mentioned objects almost completely eliminated the signal, but the signal returned in full volume immediately after clearing these obstructions.

Interference

Interference such as caused by the 33,000 volt transmission line which passed through Van Buren, Ark., and parallels the track at various places, totaling about thirty-five miles, made tuning very difficult. When the cars were parked near this line, which was about seventy feet away in some places, reception would be completely ruined.

Farm lighting plants and battery charging outfits located near where the cars were parked were bothersome at times, but never really ruined any reception. In some instances, where automobiles were parked alongside the cars and near the radio outfit and the engines allowed to run, the ignition system would cause slight interference.

On the night of February 24th, while the train was standing in the depot at Little Rock, Station WFAA—Dallas, Tex., was tuned in on the loud speaker reasonably clear and loud. The train pulled out about 9:30, headed for Van Buren, and reception continued, although it was not so clear as when standing still, due to vibration.

Stations were tuned in until after 1 A. M. for the benefit of persons who were at the depots along the line.

The radio furnished music, speeches and market reports for the train audiences while they visited the cars and enjoyed the motion pictures on cotton growing.

Several broadcasting stations favored the train with special speeches and programs.

The Second Train

The second Agricultural Progress train, which consisted of six cars operated in Missouri, was equipped with two complete radio outfits. One was an Atwater Kent, which remained on the train to furnish programs

Typical Crowd That Gathered Around Train to Hear the Radio Programs

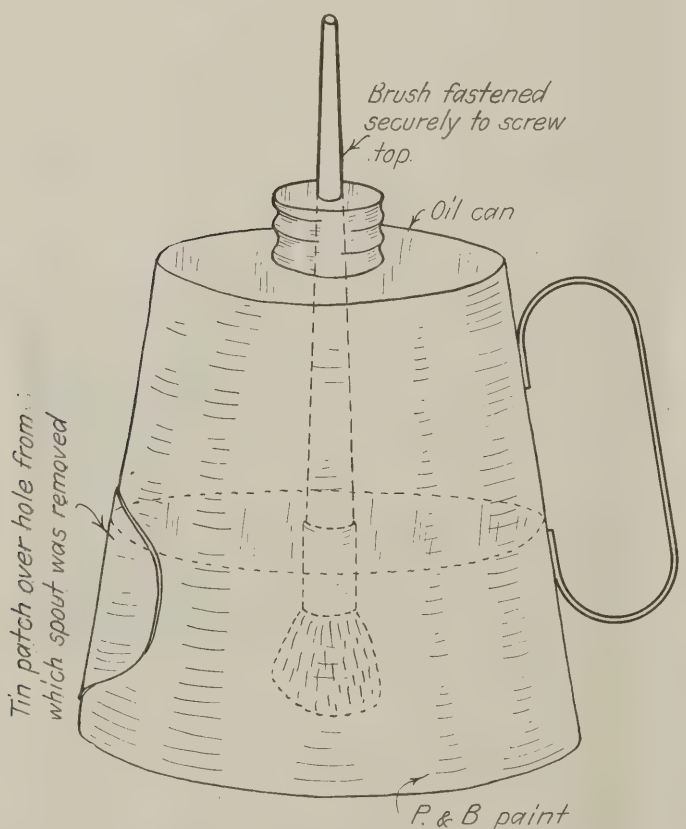
for the train audiences in the lecture car, and a Murad set which was taken to the meeting places, which were used when the lecture car could not accommodate the crowd. The latter set was very well adapted for this kind of service, as it employed a loop instead of an antenna and ground.

The set using the outside antenna worked on the train when in motion better than the set using the loop antenna, due to the fact that when a station was tuned in on the outside antenna set, the volume would be almost uniform without further adjustments, but with the loop antenna outfit some difficulty was experienced in holding a station after it was tuned in.

Keeping P. & B. Brushes in Proper Shape

Keeping paint brushes soft and serviceable is a problem for anyone that does not use the brushes every day in their work. I find that an electrician has little time to spend cleaning and preserving P & B brushes every time he is through using them, and if this is not done the brush is usually a total loss.

I have devised the following combination brush and can top, to permit keeping the brush in contact with P & B paint. As shown in the sketch, an oil can is converted into a paint can, by removing the long spout and soldering



Paint Can with Combination Brush Holder and Cover

a tin patch over the hole. The brush is fastened air-tight, through the screw top, and when using the brush simply unscrew the top and apply P & B paint. When not in use, always keep the combination brush and can cover screwed firmly in place. As long as the brush stays in the paint it will not get stiff. I know of one brush that was kept intact in this way for five years.

Aerial Insulation for Radio Equipment

By A. H. Mathews

In installing radio on railway coaches a very important item is insulation, and the lack of attention to this particular feature is the cause of many failures. The aerial should be properly insulated from its supports and the insulators should be of such construction that they will shed dirt and water freely. Smoke and coal dust make an excellent conductor of electricity and carry a part of the current of the earth causing a loss of capacity as well as a noisy outfit. To lose capacity in the aerial means that you will be unable to tune out local interference as for example, a car lighting generator. For best results special strain insulators should be used and the lead-in wire should be insulated between its connection of the aerial and the connection to the instruments. The amount of noise that a dirty connection will cause is surprising and for this reason every joint and connection should be cleaned, and soldered if possible.

It should be remembered that it is well to treat radio as a high tension transmission line. No one would think of using glass insulators on a 100,000 volt line, and yet some of the finest receiving sets are often found connected to very poorly insulated aerials. A number of cases which have come to my attention apart from the railroad application may serve to illustrate.

I recall one installation in which the aerial was placed on a roof on poles 10 feet high, the aerial itself consisting of four strands of No. 12 cable, each strand insulated from the spreaders with a high tension strain insulator. The lead-in wire was a No. 14 rubber covered wire connected to the center of the aerial and ran down to the entrance which consisted of ½ in. metal conduit fitted at the outside end with a service condulet and a single hole porcelain cover. The inside end of the conduit was also fitted with a condulet and porcelain cover and the wire ran down the inside wall mounted on porcelain knobs. The installation looked very neat, but it would not work. After a long period of discouragement, I induced the owner to install a proper lead-in insulator and his trouble ended. In another case of faulty insulation, the trouble was assigned to almost everything including a small 5 kw. motor-generator set in the basement which was used to charge storage batteries. The aerial in this case was run around the edge of the roof, mounted on short iron posts using small telegraph glass insulators and the lead-in ran down the side of the building and through a window ventilator without insulation except the covering on the wire.

The ground wire was connected to a radiator. Sometimes the set would work, but most of the time, it would not. To remedy this, I suggested that the aerial be properly insulated. This was done by placing a strain insulator at each post the lead-in insulated in the same manner and a lead-insulator installed. The ground wire was run outside the building and connected to a 10 foot length of one inch water pipe driven into the earth. A special switch was used in the lead-in so that the aerial should be connected to earth if necessary. After these alterations were made the performance of the set was nearly perfect.

In another case something similar to the latter, the aerial was installed on the roof in the usual way supported between short wooden poles using spreaders and two strands of No. 14 wire, but the lead-in was run down the ventilator stack from the roof. This set made a lot of noise which was put down to the elevator motor sparking. A condenser was put across the motor but this did not help much so that they hit upon the idea of covering the roof with tin, the present roof being covered with roofing paper. While the tin roof was a good thing for the house, it never made the least bit of difference to the radio. Finally after doing all kinds of stunts they had an electrician look it over. He installed the proper lead-in insulator, used larger insulators on the aerial, and the noise vanished. I think most radio fans forget that many of the more sensitive sets are regenerative and, if not properly set up and handled, will cause annoyance and interference to others as well as to themselves. If you install or make your own set be sure you know what you are doing. If you do not have the patience to do this properly, have an electrician do the job and if he installs it according to the underwriters' obligations, it will work and, furthermore, it will be safe in an electrical storm.

Impurities That Spoil Batteries

The harmful effect of impurities in the electrolyte of automobile and other storage batteries is the subject of an investigation now in progress at the Bureau of Standards. Results up to the present time have shown that some impurities are harmful to both plates of the battery, some to only one, while still others have no apparent effect.

The investigation has now been in progress for more than a year, the plates being immersed in electrolytes to which known amounts of impurities have been added. Provision is made for measuring easily their change in weight, and the electrolytes are kept at constant temperature by means of an oil bath.

The object of the investigation is to obtain information necessary to the successful operation of storage batteries, and to serve as a guide in the preparation of specifications for sulphuric acid for the electrolyte.

A paper is now in course of preparation embodying the results. Data obtained to the present time indicate that among the impurities which affect both positive and negative plates are iron, manganese, chlorine, and the bichromates. Bismuth, starch and sugar affect the positive plate but not the negative; while platinum, tin, copper, antimony, silver, nitrogen, and tungsten affect only the negative plate. Among the many substances which appear to produce no harmful effect are mercury, alum, titanium, calcium, zinc, cadmium, sodium sulphate, and tannic acid.

Answers to Questions

1. *Do you believe that radio antennae should be rightfully considered as a lightning menace?—H. F.*

2. *Is the head-end system of car lighting coming into style again? I have heard considerable about this from one place or another recently?—E. W.*

Radio Antennae as a Lightning Menace

1. According to the Bureau of Standards the limited extent of radio antennae prevents them from becoming a menace from lightning. On the other hand they cannot be regarded as an effective protection against lightning as is sometimes assumed. In any event they can scarcely be considered as potential inviters of lightning strokes, being in a class with other metal objects commonly found around buildings such as gutters, down spouts and wire clothes lines. As commonly installed aerials are relatively small in size, both in the extent and in diameter of the wire used. If grounded or provided with a lightning arrester, they may effect a gradual drainage of electricity as well as a lightning rod, but a direct stroke is likely to fuse them or tear them from their fastenings on account of their small diameter.

Head-End Train Lighting

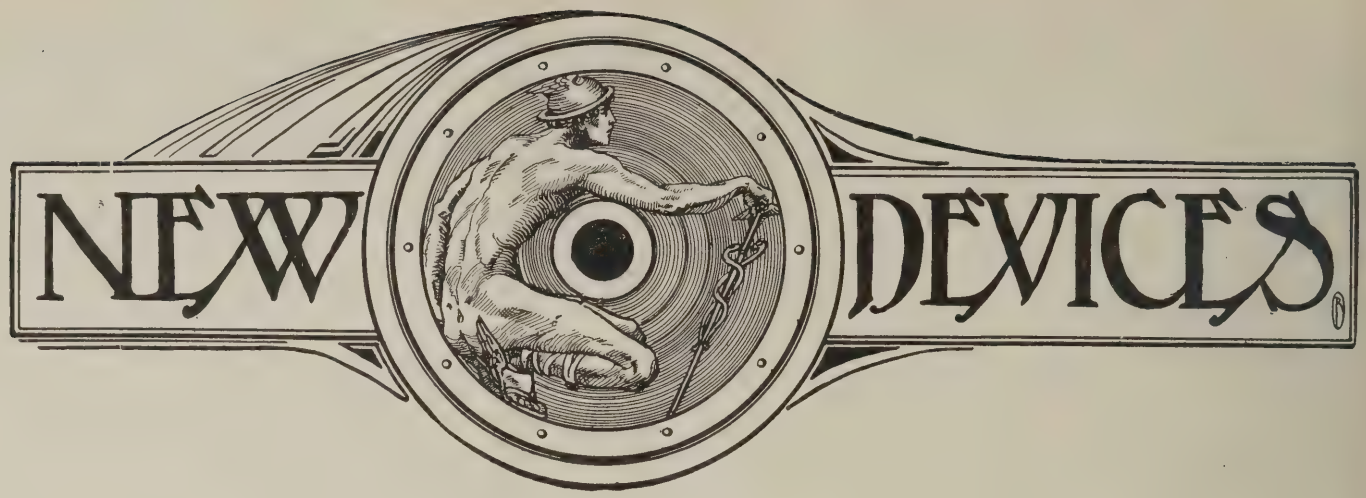
2. Originally head-end train lighting was accomplished by placing a gasoline driven generator in the baggage car of the train and the lighting circuits were supplied from this machine. This type of equipment was used to some extent but was never very popular. The head-end train lighting which has come into some use today is quite different from the older practice, in that the current is supplied from a turbo-generator located on the locomotive. This system may or may not be used in connection with storage batteries. The greatest use of such an installation is found in certain suburban service where it is possible to operate the same cars on the same train each day and where operating conditions are such that the locomotive with the proper turbo-generator can always be assigned to this particular train. The Chicago & North Western, the Rock Island and the Boston & Maine are at present operating head-end equipment with turbo-generators located on the locomotive.

It is our intention to publish in the *Railway Electrical Engineer* in the near future an article describing the new head-end lighting system as it is being installed on the Boston & Maine. As this is a decided departure from the ordinary practice of this road, the development of the new system will probably be watched with much interest by many car lighting men who are contemplating an installation of a similar kind on their own roads.

Questions for December

1. *Is it possible to measure resistance with a voltmeter and if so, how can this be done?—G. H.*

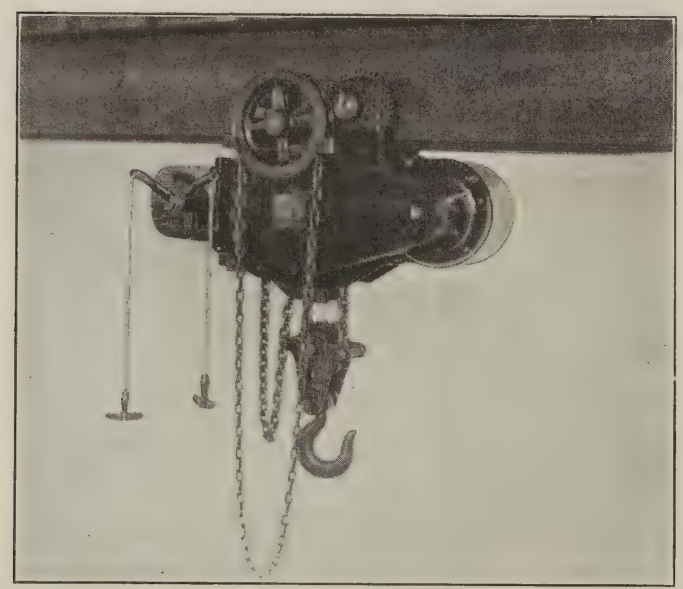
2. *I would like to have you explain the operation of a Wheatstone bridge. How is this apparatus used in finding faults in underground telephone cables?—M. H.*



An Electric Hoist Requiring Small Head Room

An electrically operated chain hoist adapted to the rapid handling of light material has been placed on the market by The Clinton E. Hobbs Company, Boston, Mass. The hoist has been constructed to permit its installation in locations where only low head room is available.

The hoist is of steel construction and completely enclosed. The main drive is by means of a roller chain driving through a heat treated steel cut pinion and sprocket. The hoist is always in balance with or without a load. The



A Hoist Adapted to the Rapid Handling of Light Material

center of support is directly over the center line of the load chain. It is lubricated by the Alemite system. This system provides a main reservoir to oil tight main gear case and distributes the oil to all internal parts which greatly helps to reduce frictional resistance.

The machine is equipped with three different types of brakes. The first type locks the load against downward travel; the second provides the lowering friction and has ample surfaces for the dissipation of the heat generated during the lowering, and the third is an external automatic band brake which prevents the drifting of the load when the current is shut off. This brake is adjustable against a spring which actuates it.

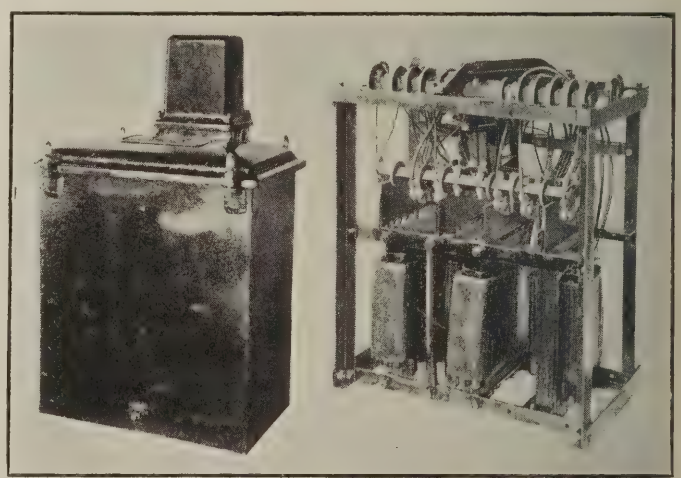
The hoist is suspended by two heavy steel plates which directly suspend the chain sheave bearings, relieving the hoisting mechanism of all load stresses and providing a steel suspension for the load from hook to hook. This construction makes these hoists applicable to any type of trolley or upper support. Any method of suspension desired can be furnished but the three standard types are hook suspension, plain trolley suspension and geared trolley suspension.

The hoist is provided with an automatic stop at the top of the travel that will reverse the motor if necessary, which produces ample protection against over travel. This stop is self-resetting. The hoist has a factor safety of six throughout.

Automatic High Voltage Compensator

An automatic high voltage compensator has been placed on the market by the Electric Controller & Manufacturing Company, Cleveland, Ohio.

This compensator is built for voltages 2,500 and below.



The Compensator Complete and Compensator Mechanism Removed from Tank

It is push button operated and entirely automatic. With the exception of the overload panel, which is mounted on top of the tank, the compensator is entirely submerged in oil and the tank is so designed that the compensator is dust-proof, weather-proof, vapor-proof and fire-proof. It can be installed either indoors or outdoors.

A push button operates an independent low voltage circuit which is taken from an independent transformer so that there is no danger of the operator coming into contact with the high voltage circuit. Having the starting transformers and the operating mechanism entirely submerged in oil and automatically operated reduces to a minimum the possibility of explosions or high voltage flashes.

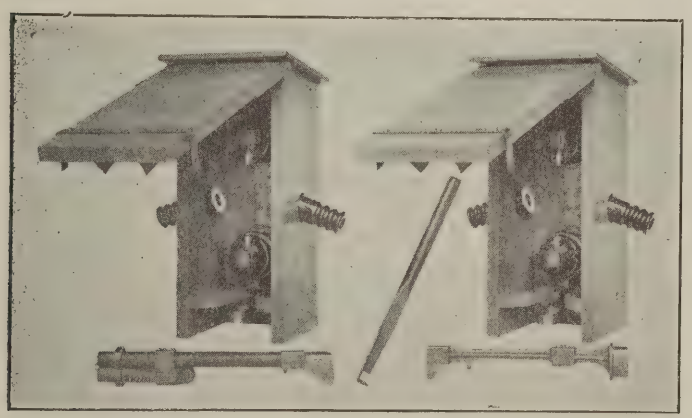
The compensator is so designed that continuous torque is applied to the motor from the time the push button is pressed until the motor has been brought up to speed.

Operating the starting switch causes the motor to be started under reduced voltage obtained from the transformers in the compensator and after the motor has reached the proper and safe speed it is automatically thrown across the line by the compensator.

Fuse Switch and Disconnecting Switch

A fuse switch known as the type OK Matthews "Fuswitch" which can also be used as a straight disconnecting switch has been developed by the W. N. Matthews Corp., St. Louis, Mo. This device, made for protecting the primary side of power transformers, is also designed to protect the trouble man from possible contact with the high voltage line and to make refusing a simple matter.

The box in which the fuse and fuse-supports are housed is made of cypress, the roof being made of specially treated plywood that is moisture proof. All parts of the box are soaked in boiled linseed oil before they are fastened together with heavy brass screws. When assembled, the box is given a coat of gray insulating and weather resisting paint that will stand a surface leakage test of several thousand volts to the inch. The lead-in wires are brought in through porcelain entrance bushings. The fuse clips or female contacts are supported on porcelain insulators. Both bushings and insulators are made of wet process porcelain. The clips are made of bus bar



The Matthews "Fuswitch," Left, and Disconnecting Switch, Right, With Fuse Tube and Switch Blade Removed. The Switch Hook Is Shown in the Center

copper, reinforced by bronze springs to keep them in alignment and assure good contact. The switch has been tested to stand flashovers of at least four times its rating of 7,500 volts.

The vacuum principle cartridge is of unique design. It consists of upper and lower copper contact castings with screw plug fuse holders and milled contact faces. These are joined together with seasoned horn fibre tubing. The fuse wire runs from the upper contact through the long tube and back through the short tube to the lower contact. When the fuse blows the rush of gas past the open end of the short tube creates a vacuum in which the arc is extinguished in its attempt to get to the lower contact. As many as 50 fuses have been blown in one tube without damaging the tube.

The box can be opened for inspection without opening the line. When the door of the box is shut the bottom of the box is entirely closed so that birds cannot get in and the metallic gases from blowing fuses cannot get back to establish an arc which would destroy the box.

When a straight disconnecting switch is desired, a brass link is supplied which can be used in place of the fuse cartridge. A switch hook is used in either case for opening the line, the brass blade or fuse cartridge, as the case may be, being pulled completely out and away from the two contact clips. The switch is suitable for voltages of 7,500 or less and can be used up to 100 amperes.

Dry Type Glue Pot with Rheostat Temperature Control

To retain those qualities that give it maximum adhesiveness, glue must be carefully heated and handled. Changing climatic conditions and different grades of glue tend to vary the temperature to which glue must be heated. This, with the requirements of different temperatures to produce certain results, has made heat control of the glue pot a necessity, if all conditions are to be met successfully.

The Glue Can Be Kept at Any Desired Temperature by Setting the Rheostat

To meet the demand for a glue pot of this kind, the Westinghouse Electric & Manufacturing Company has designed a pot equipped with a rheostatic control. This new device gives a wide range of heat control and at the same time keeps the unit simple and inexpensive. It also permits almost unlimited variation in the wattage input and in temperature.

The unit is a portable device, as the rheostat can be laid on a bench or shelf or hung on a wall while a cord between the rheostat and the glue pot permits the glue pot being moved over a large radius. The convenience of having the glue pot at the best location saves many steps.

The dry type glue pot is used with this new unit because of its many advantages over the wet type. The inconvenience of refilling the water bath is eliminated. Danger of the pot boiling dry and burning out is eliminated.

Simplicity and sturdiness mark the construction of the glue pot, the casing and bottom plate being made of heavy sheet steel and the glue vessel of heavy spun copper. The glue vessel can be removed for cleaning.

General News Section

The Strom Ball Bearing Manufacturing Company, Chicago, Ill., announces the appointment of Alfred G. Norris to the position of manager of the New England branch with offices at 75 Pearl street, Hartford, Conn. A. W. Weise, sales engineer, has been transferred from the Philadelphia office to the new office in Hartford.

A fine of $1,000 was imposed on the Central Railroad of New Jersey in court at Elizabeth, N. J., on November 28, on account of a fatal accident at a grade-crossing in Bayway, on October 20. Both the railroad company and the crossing gateman were indicted on charges of manslaughter. The trial of the gateman is not yet reported.

The Gibb Instrument Company, Bay City, Michigan, has changed its name to Gibb Welding Machine Company. This is a change in name only and denotes no change in organization. As the company no longer makes instruments but is engaged exclusively in the manufacture of electric welding and heating machines, the new name was adopted as more exactly descriptive of the product.

An amusement center, the principal feature of which will be a huge seawater swimming tank surrounded by a promenade, will be constructed by the Canadian Pacific on a site immediately east of its Empress Hotel at Victoria, B. C., at a total cost of $225,000. The contracts for the construction of the amusement center, which will be known as "Crystal Garden," have already been awarded and the work is to be completed by May 15, 1925.

An express train bound from Liverpool, England, to Blackpool on the London, Midland & Scottish on November 3 was derailed between Kirkham and Lytham, resulting in the death of seven persons and injury to many more. The cause of the derailment was not established. The train collided with a signal tower which was overturned as was the locomotive and two coaches. The wreckage caught fire.

One passenger was killed and 25 were injured when Pennsylvania passenger train No. 201, from Cincinnati, ran into the rear of train No. 109, from Pittsburgh, a short distance north of Englewood station, Chicago, on December 1, telescoping the rear car of the leading train. A signal at the station being out of order the engineman of 201 was given a hand signal, by the towerman, to proceed out of the station. But, because of a drawbar pulling loose train No. 109 was unexpectedly brought to a stop.

The Illinois Central has entered into a contract with the Commonwealth Edison Company of Chicago whereby the latter will furnish the electric power necessary in the operation of the electrified portion of the Illinois Central within its Chicago terminal district. The Commonwealth Edison Company will erect seven substations along the railway from the Chicago passenger terminal to Matteson and also to South Chicago and Blue Island. It is now planned to complete the electrification of the Chicago terminal for suburban passenger service by the summer of 1926.

The Long Island Railroad committee on Public Relations has distributed posters throughout the United States, containing what is believed to be the most comprehensive radio program ever prepared for broadcasting in a single evening by one railroad system. This program will be broadcast from station WAHG, Richmond Hill, Long Island, N. Y., on December 15. The program will be almost entirely musical and will require four hours to complete. Almost one hundred entertainers will be required—all of them employees of the railway.

Supplementing laboratory and factory tests on high voltage cable, a field test on a commercial length operating at 110,000 volts is being made by the General Electric Company. For this test a 200-foot length of single conductor cable is connected to the system of the Adirondack Power and Light Corporation at its North Albany Station, Albany, N. Y. This is the highest voltage at which a lead sheathed cable has been operated in this country. The nearest approach is the 66,000 volt cable used by the Cleveland Electric Illuminating Company.

Electrification Activities in Europe

According to F. H. Shepard, director of heavy traction of the Westinghouse Company who has recently returned from Europe, the general activity in electrical undertakings on the continent is most noteworthy. The electrical business can be said to exceed greatly any pre-war conditions. Railroad electrification is in progress and already in operation over sections of railways in Norway, Sweden, Germany, Austria, Switzerland and Italy, aggregating some two and one-half million horsepower in locomotives built and building, all using alternating current systems either single or three-phase. In France, Spain and Holland, the direct current system is used, about 600,000 horsepower in locomotives are already built or are being built at the present time.

While a large amount of equipment has been manufactured in America in the past, the urge for national industries in the respective countries will lessen the proportion of this in the future. America's experience and engineering position in the electrical art are, however, universally accepted as essential to their undertakings. It may, therefore, be expected that American participation will continue for a long time to come. It should be noted that the trend throughout Europe is towards greater efficiency in electrical and railroad undertakings. Mr. Shepard found the opinion unanimous that the result of the recent elections both in America and England would stabilize

world conditions for several years to come which would be attended by a conspicuous increase of industrial activity throughout the world.

New York Railroad Club Dinner

The annual dinner of the New York Railroad Club will be held at the Hotel Commodore on Thursday evening, December 18. Dr. David Friday will speak on "What the Future Holds for the Railroads." Dr. Friday is professor of economics at the New School for Social Research, New York, and a consulting economist specializing in railway and financial problems. He was formerly president of the Michigan State Agricultural College, and prior to that was professor of economics at the University of Michigan and at New York University. While at the University of Michigan he frequently served as an expert in railway and public utilities valuation cases. During the war he served as an expert on taxation in the Treasury Department at Washington. Recently he has been called upon several times by the railroads for testimony in rate cases before various commissions.

Col. Douglas I. McKay, president of the Standard Coupler Company, is chairman of the Dinner Committee. Reservations for places should be made through F. O. Schramm, chairman of the Seating Committee, Pressed Steel Car Company, 55 Broad street, New York.

Illinois Central Orders Multiple Unit Equipment

The Illinois Central has announced the placing of an $8,250,000 order for electrification equipment. This includes 130 motor cars and 85 trail cars.

The electrified lines will be those now operated by steam locomotives between Randolph Street Terminal, Chicago, and Matteson, Illinois, Kensington and Blue Island on the Blue Island Branch, and between Sixty-seventh Street and South Chicago on the South Chicago Branch. The railroad will operate 20.5 miles of double track, 9 miles of four track and 3.75 miles of six track road, and 4.5 miles of single track with the 1,500 volt direct current system. This electrified section will be complete an in operation by July, 1926, according to the present plans.

The motor car order was awarded to the Pullman Car and Manufacturing Company, the trailer order to the Standard Steel Car Company; the General Electric and Westinghouse Electric and Manufacturing Companies will supply the motors and the control and lighting equipment will be supplied by the General Electric Company.

Each motor car, weighing 62½ tons, will be equipped with four 250 hp. direct current motors, operating two in series on 1,500 volts. Each motor car will be semi-permanently coupled to a trailer, weighing 42 tons. The train make up will vary between two and ten cars according to the service requirements and will be composed of units consisting of two cars semi-permanently connected. One car of this unit will carry the four propulsion motors with control apparatus. The second car being a trailer is equipped only with the necessary electrical apparatus for lighting, heating, signalling and door operation. The coupling between the car units which make up the train will be completely automatic both in respect to the air and control cable connections. Motor cars and trailers are each 72 ft. 4 in. long over platforms and seat 84 persons. Aluminum and aluminum alloy metals will be extensively employed in the car superstructure and much attention has been given to the arrangement of seats, heating, ventilation and illumination.

Separate motor-generator sets on each car will supply current for lighting the cars. These sets will be so regulated that constant voltage will be delivered to the lamps.

The initial installation of cars provides for a train movement of approximately four minute intervals during the morning and evening rush hours. The cars are designed for a maximum train speed of 57 miles an hour at 1,350 volts. The nominal horsepower of a ten car electric train will be 5,000 and that peak power developments of this train at 1,500 volts will exceed 6,000 hp. Two pantographs will be provided on each motor-car, one for regular operation and the second for emergency operation.

Personals

Arthur J. Manson, manager of the transportation division, railway department, of the New York office of the Westinghouse Electrical & Manufacturing Company, has been appointed to the position of manager of the heavy traction division, railway department, at Pittsburgh, Pa., effective November 1. After being graduated from the Massachusetts Institute of Technology in 1905, he entered the company's engineering apprentice course and assisted in the building and testing of the first electric locomotive for the New York, New Haven & Hartford. In the spring of 1907 he was assigned to the electrification work on this road and aided in the inauguration of the electric service. In this position he instructed the steam enginemen in their duties as electric enginemen. Mr. Manson was associated with the preliminary test conducted by the Pennsylvania Railroad on Long Island prior to the decision as to the system to be used in the Pennsylvania tunnels entering New York City. Later he became associated with F. H. Shepard, director of heavy traction, entering the New York office of the Westinghouse Company. He assisted Mr. Shepard in connection with the Pennsylvania contract for power house, substation and locomotives for the Pennsylvania New York tunnel electrification. In 1910 Mr. Manson entered the sales department of the New York office following construction, subway and elevated work. In 1920 he was made manager of the transportation division of the New York office which position he held at the time of his recent appointment. During the time when Mr. Manson was manager of the transportation division he wrote and published a book entitled Railway Electrification.

A. J. Manson

George N. Roberts has been appointed district sales manager of the Chicago Fuse Manufacturing Company, filling the position formerly occupied by J. B. Martin, who has resigned. Mr. Roberts will have charge of the New York office of this company.

K. A. Simmon, manager of the light traction division of the Westinghouse Electric & Mfg. Company, was recently appointed to the position of assistant to the manager of the railway department. Mr. Simmon entered the employ of the Westinghouse company upon his graduation from the University of Minnesota in 1905, He attracted attention through the development of train heating boilers for the New Haven locomotives. Railway control was his special work for some time and he became head of the railway control section of the railway engineering department in 1914. Four years later he became section engineer in charge of light traction motors and control in the railway engineering department. In 1921 he was appointed manager of the light traction division of the railway department.

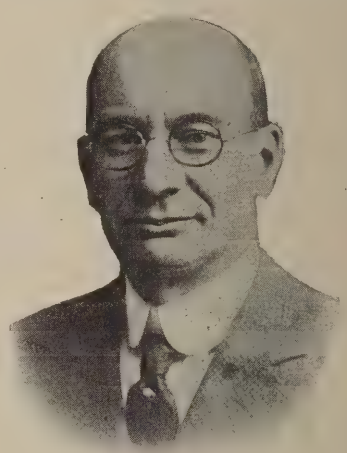
K. A. Simmons

E. A. Palmer, manager of the transportation division of the Westinghouse Electric & Mfg. Co. at San Francisco, was recently appointed to the position of manager of the light traction division. Mr. Palmer entered the employ of the Public Service Railway Company of New Jersey upon his graduation from Cornell University in 1909 and after spending two years in the transportation, track, power and mechanical departments, was appointed assistant superintendent of the Plank Road shops in 1911. Three years later he was appointed division master mechanic of the central division, with headquarters at Elizabeth, N. J., which position he held until 1916, when he entered the employ of the American Brake Shoe and Foundry Company as mechanical expert. He was engaged by the Westinghouse company in 1917 and was assigned to the railway department of the San Francisco office.

E. A. Palmer

G. E. Emmons, vice president in charge of manufacturing of the General Electric Company, Schenectady, N. Y., has announced his intention to retire from his duties in this connection. Mr. Emmons, who has been identified with the electrical industry for nearly 40 years, expects to move to Pasadena, Calif., which will thereafter be his home. Mr. Emmons has been actively engaged in the management and development of the manufacturing department of the General Electric Company for nearly 30 years. During his administration the Scehenectady plant attained its present immense proportions and he has also been instrumental in the development of the company's plants in other places.

W. R. Stinemetz, manager of the heavy traction division of the Westinghouse Electric & Manufacturing Company, was recently appointed to the position of assistant to the manager of the railway department. Mr. Stinemetz, following his graduation from Lehigh University in 1893, was employed by the Chicago Telephone Company and the Brooklyn Edison Company. He entered the employ of the Westinghouse Electric Company in 1897, was electrical engineer for the power-house of the Third Avenue Railroad, New York, in 1899, and in 1900 was employed by the Westinghouse agents in Mexico. In 1901 he worked on the electrification of the Boston Elevated Railroad. He spent two years supervising the installation of single-phase roads in France. In 1913 he was employed as a commercial engineer in the railroad department of the Westinghouse company and several years ago was made manager of the heavy traction division of the railway department, which position he retained until his present appointment.



W. R. Stinemetz

Trade Publications

The Bryant Electric Company, Bridgeport, Conn., recently issued its latest and most complete catalog containing listings and descriptions of more than 5,000 Bryant wiring devices. The catalog is issued in three styles, "A" a loose-leaf style, 8½ in. by 10 in., for use by jobbers and large dealers who wish to receive up-to-date price information and will keep the loose-leaf catalog up-to-date, "C" a large bound style, 7½ in. by 10⅝ in., and a miniature style 4⅝ in. by 6¼ in. for pocket use.

The Westinghouse Electric and Manufacturing Company has recently issued a 16 page publication entitled "Westinghouse Precision Instruments" and devoted to the construction, operation and performance of precision voltmeters, ammeters and wattmeters manufactured by that company. The booklet, which is known as Folder Number 4603, gives complete information for the connection, reading and adjustment of Westinghouse precision instruments and for their application as standards for the calibration of other instruments and meters.

Power

Railway Electrical Engineer

Illumination

Heavy Electric Traction Train Lighting Electric Welding

VOLUME 15 DECEMBER, 1924 NUMBER 12

UNIVERSITY OF ILLINOIS
DEC 10 1924

1924 1925

May your friends and our friends be friendly happy and prosperous

THE SAFETY CAR HEATING & LIGHTING COMPANY

New York Chicago St Louis Boston

Philadelphia San Francisco Montreal

FUME-PROOF

This EC&M Automatic Compensator is still working after four years with no trouble of any kind.

Think of what it has been through. It operates a motor driving a gas producer and gases are in the air all the time.

It is located outdoors and gets 100° weather in the summer and zero weather in the winter.

It has been rained on and it has been snowed on.

Yet it is still working after four years without a failure.

EC&M Automatic Compensators can be supplied for any voltage up to 2300 volts.

Write for Bulletin 1042-D

THE ELECTRIC CONTROLLER & MFG. CO.

BIRMINGHAM-BROWN-MARX BLDG.
CHICAGO-CONWAY BLDG.
CINCINNATI-1ST NATIONAL BANK BLDG.
DENVER-3535 WALNUT ST.
DETROIT-DIME BANK BLDG.

CLEVELAND, OHIO

LOS ANGELES-THOMAS MACHINERY CO. AMERICAN BANK BLDG.
NEW YORK-50 CHURCH ST.
PHILADELPHIA-WITHERSPOON BLDG.
PITTSBURGH-OLIVER BLDG.
SAN FRANCISCO-CALL BUILDING
SEATTLE-524 1ST AVE. SOUTH
TORONTO-TRADERS BANK BLDG.

Volume 15 **Number 12**

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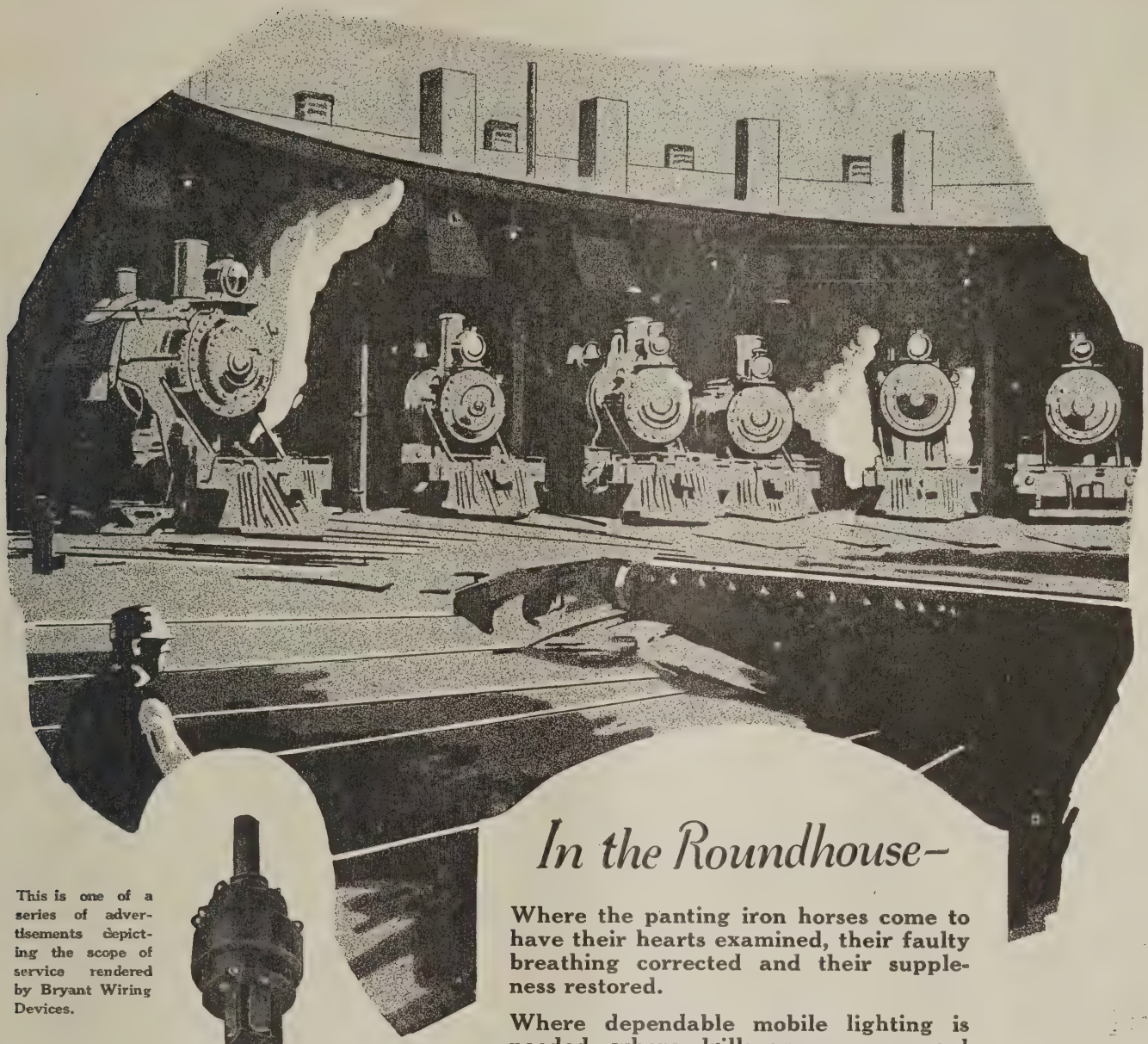


This is one of a series of advertisements depicting the scope of service rendered by Bryant Wiring Devices.

No. 588

In the Roundhouse–

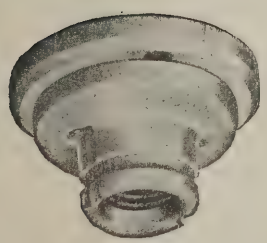
Where the panting iron horses come to have their hearts examined, their faulty breathing corrected and their suppleness restored.

Where dependable mobile lighting is needed, where drills are manoeuvered into tight corners, where rugged wiring devices mean the saving in dollars and cents of many hours of expensive man power.

There are Bryant Superior Wiring Devices for use in the Roundhouse.

Their initial cost is probably no more than you are now paying.

Suppose you specify Bryant Wiring Devices the next time the need arises for the Roundhouse, or elsewhere. No matter where you are you can get them quickly—and they will stand the gaff.



No. JT-720

No. 583

BRYANT SUPERIOR WIRING DEVICES

"A Superior Wiring Device for every Electrical Need"

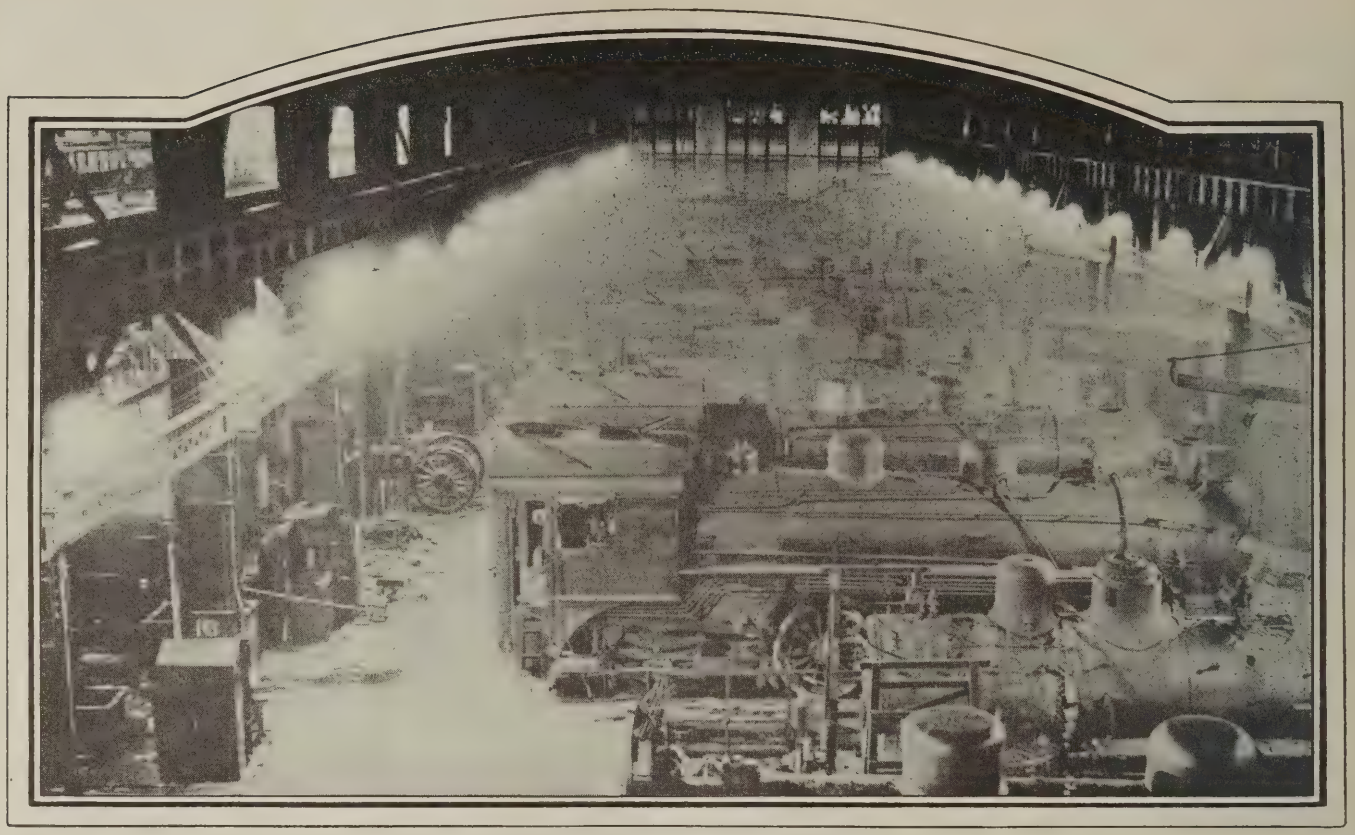
THE BRYANT ELECTRIC COMPANY

1421 STATE STREET, BRIDGEPORT, CONNECTICUT

NEW YORK
342 Madison Ave.

CHICAGO
844 West Adams St.

SAN FRANCISCO
149 New Montgomery St.



The Low Cost of Good Lighting

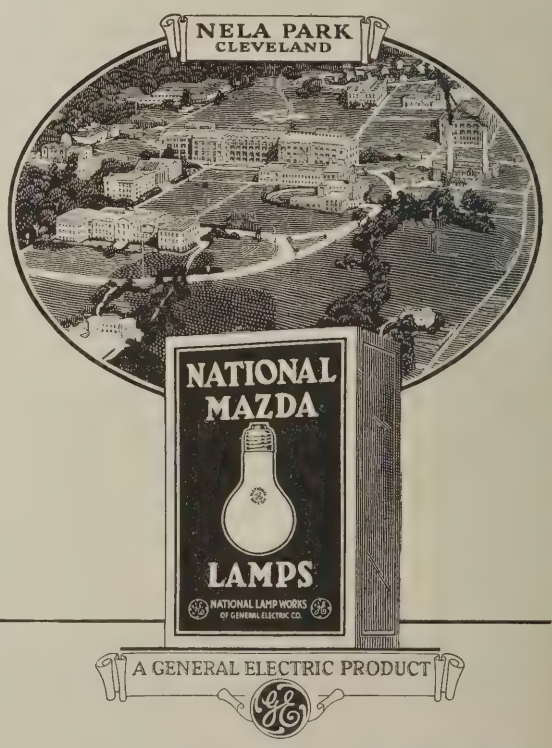
THE cost of lighting can not be measured by your lighting bills.

A close analysis of the many factors entering into the cost of lighting will disclose many other factors which must be taken into consideration.

Experience shows that improved lighting will increase the efficiency and usefulness of your men to such an extent that the current cost represents a saving rather than an expense.

Good lighting is also an important factor in preventing accidents. One accident will cause more discontent and cost more than many times the lighting bills for that particular section. Poor light is costly.

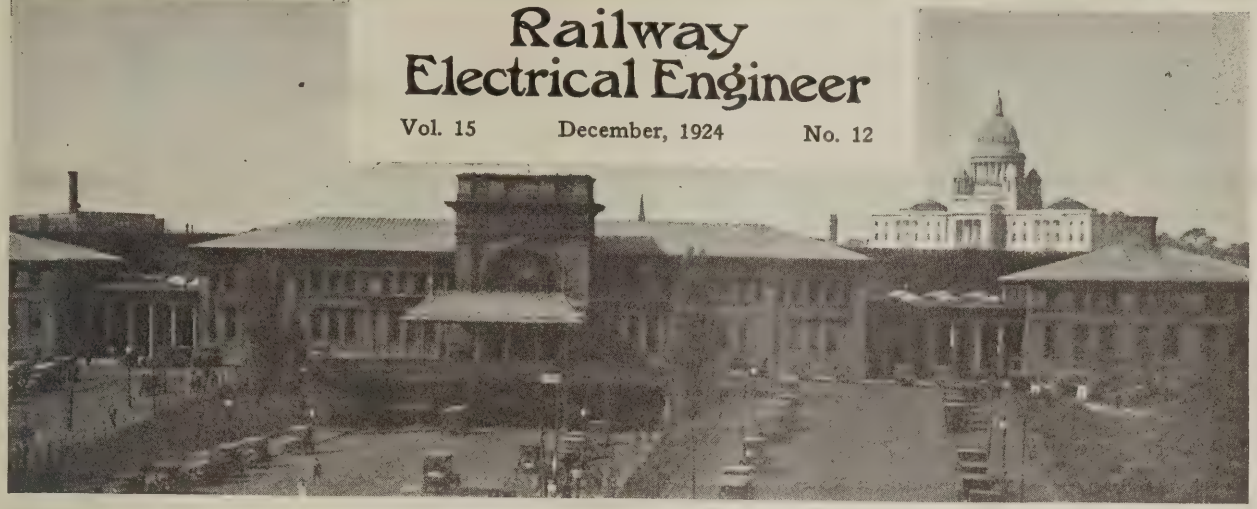
Our Engineers will gladly study **your** shop conditions and show you how to change the high cost of poor lighting to the low cost of good lighting. National Lamp Works of General Electric Company, Nela Park, Cleveland, Ohio.



NATIONAL MAZDA LAMPS

Railway Electrical Engineer

Vol. 15 December, 1924 No. 12



The New Haven's Station at Providence, Rhode Island, State Capitol in Background.

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REQUEST for change of address should reach us two weeks before the date of the issue with which it is to go into effect. It is often impossible to supply back numbers to replace those undelivered through failure to send advance notice. In sending us change of address please be sure to send us your OLD address as well as the NEW one.

The Railway Electrical Engineer is a member of the Associated Business Papers (A. B. P.) and of the Audit Bureau of Circulation (A. B. C.)

Additional Electrification

Multiple-Unit Train of the Long Island Railroad

Each car equipped with two No. 308 Motors, 215 hp. each, and electro-pneumatic control.

THE Long Island Railroad is extending its electrification approximately 20 miles to Babylon, in order to more efficiently handle the tremendous traffic in and out of New York City, which traffic has increased over 450% since 1905.

The order for the complete substation equipment for this extension, consisting of 10 rotaries with their transformers and switching equipment, has been placed with the Westinghouse Electric & Manufacturing Company.

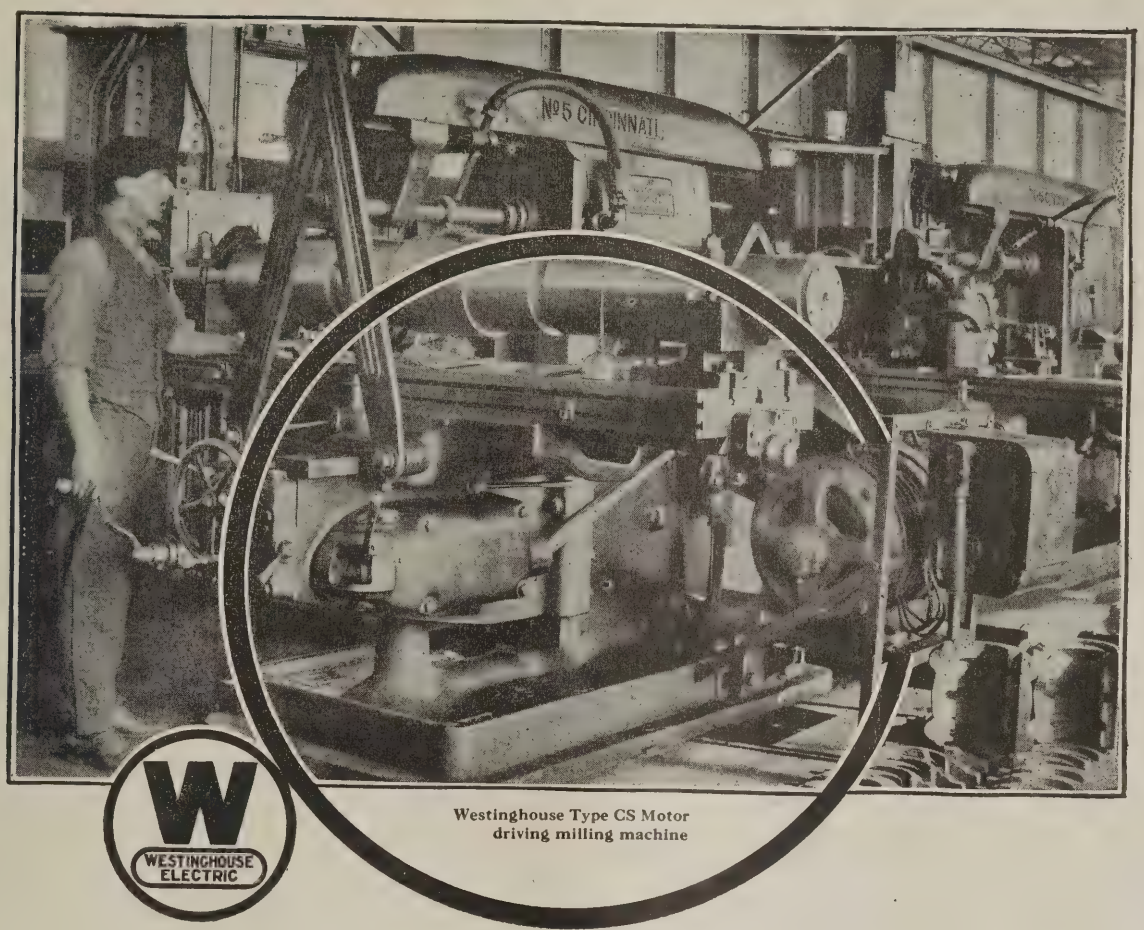
In addition, 40 motor-car equipments have been purchased, making a total of 638 Westinghouse Multiple-Unit Equipments available to assist the Long Island Railroad to maintain 100% service.

Westinghouse Equipment Leads the Way

Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
Sales Offices in all Principal Cities of the
United States and Foreign Countries.

WESTINGHOUSE ELECTRIC

Westinghouse



Westinghouse Type CS Motor
driving milling machine

Place this Motor on Your Equipment

YOU will find the Westinghouse Type CS Motor one that can always be depended on to serve through all the exacting conditions in the railroad shop.

It will stand up for years through vibration, dust, dirt, and neglect. It will operate economically and few repairs will ever be required.

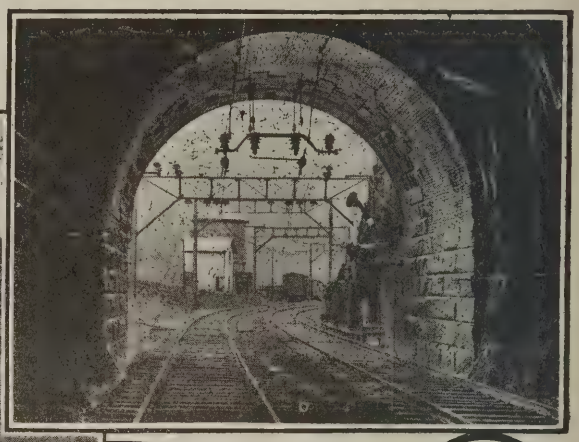
When you want a constant speed motor that is economical in performance and that will last for years, select the Westinghouse Type CS.

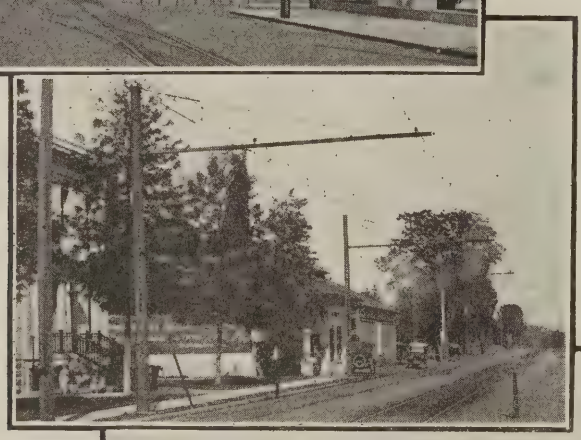
Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
Sales Offices in All Principal Cities of
the United States and Foreign Countries

Westinghouse

Expert Catenary Construction Service

Some Westinghouse Installations





Long and extensive experience in the design, development and installation of catenary line material on interurban electric systems, and on many important steam roads, qualifies the Westinghouse Company to give expert catenary construction service.

Westinghouse engineers are prepared to advise in the selection of suitable catenary line material and to give estimates of the cost of complete catenary systems best suited to the proposed installation. This service is rendered without cost.

Westinghouse Electric & Manufacturing Co.
East Pittsburgh, Pa.
Sales Offices In All Principal American Cities.

Westinghouse

A Simple Device

that never fails to function—

The Westinghouse Turbine Governor

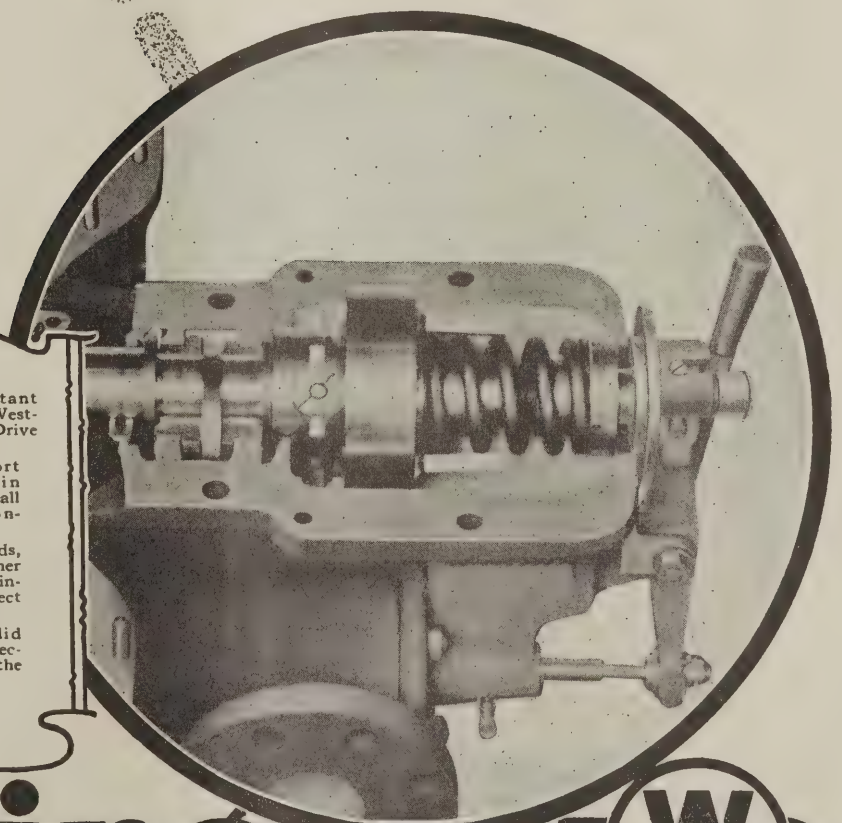
THE powerful governor of the Westinghouse Mechanical Drive Turbine is sensitive to the slightest load fluctuation in the turbine speed.

Its body is a solid casting. The governor weights are of hardened steel with integral knife edges. Loose knife edges are therefore eliminated.

No lubrication is required in any part of the governor.

The governor cannot bind. Its complete mechanism is an excellent example of mechanical simplicity that always contributes to the proper functioning of the Westinghouse Mechanical Drive Turbine.

Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
Sales Offices in All Principal Cities of
the United States and Foreign Countries



A few other important characteristics of the Westinghouse Mechanical Drive Turbine:

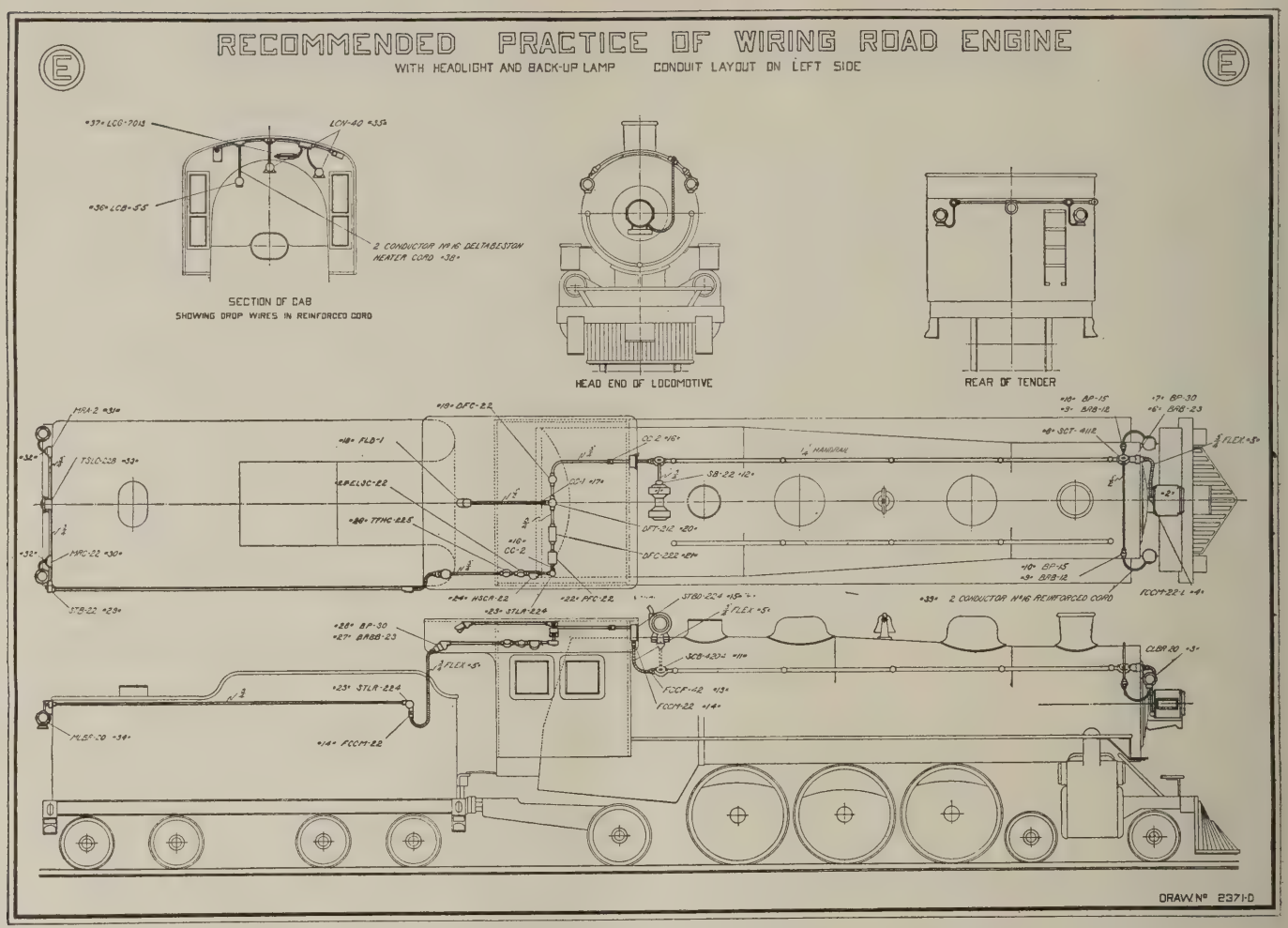
The center support keeps the shaft in alignment under all temperature conditions.

Water-sealed glands, that require neither adjustment nor maintenance, form perfect steam seals.

The rotor, of solid forged steel, is especially reinforced at the hub.

Westinghouse

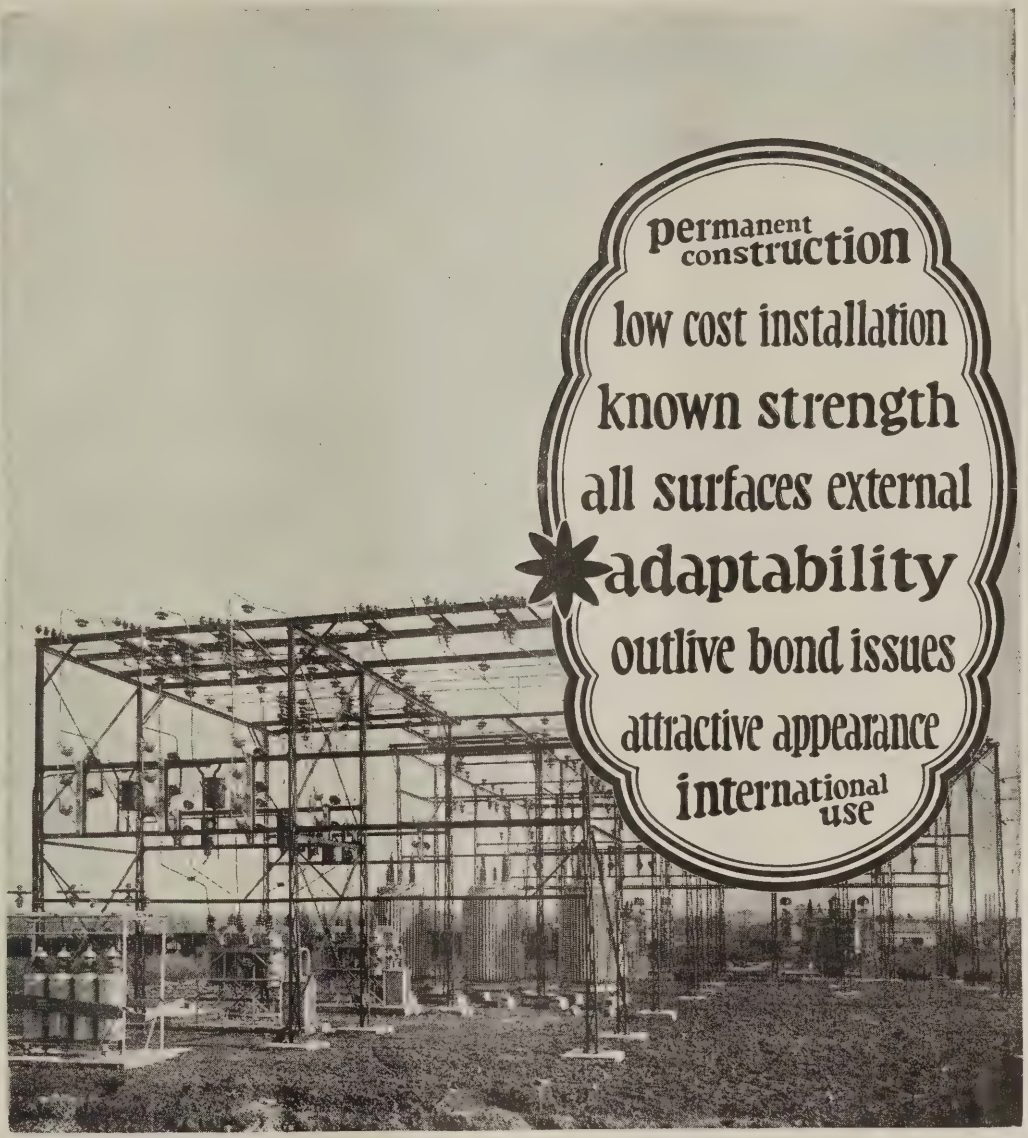
WESTINGHOUSE ELECTRIC


RECOMMENDED PRACTICE OF WIRING ROAD ENGINE
WITH HEADLIGHT AND BACK-UP LAMP CONDUIT LAYOUT ON LEFT SIDE
SECTION OF CAB
SHOWING DROP WIRES IN REINFORCED CORD
HEAD END OF LOCOMOTIVE
REAR OF TENDER
2 CONDUCTOR NO 16 REINFORCED CORD
DRAW. Nº 2371-D

BILL OF MATERIAL FOR WIRING ROAD ENGINE IN ACCORDANCE WITH DRAWING No. 2371-D

Item	Quantity	Catalog Number	Description
1	1	PYLE—NATIONAL	Turbo Generator
2	1	PYLE—NATIONAL	Headlight case
3	2	C. L. B. R.—20	Classification lamp
4	1	F. C. C. M.—22—L.	Flexible Conduit coupling
5	15′	H. A.—22	¾ inch flexible conduit
6	1	B. R. B.—23	3 wire receptacle
7	1	B. P.—30	2 wire plug for above receptacle
8	1	S. C. T.—4112	Screw cover terminal box
9	2	B. R. B.—12	2 wire receptacle
10	2	B. P.—15	2 wire plug for above receptacle
11	1	S. C. B.—4204	Screw cover junction box
12	1	S. B.—22	Outlet fitting
13	1	F. C. C. F.—42	Flexible conduit coupling
14	2	F. C. C. M.—22	Flexible conduit coupling
15	1	S. T. B. D.—224	Terminal box
16	2	C. C.—2	Conduit unions
17	1	C. C.—1	Conduit union
18	1	F. L. D.—1	Deck light fixture
19	1	D. F. C.—22	Cab light connection fitting
20	1	D. F. T.—212	Cab light connection fitting
21	1	D. F. C.—222	Cab light connection fitting
22	1	P. F. C.—22	Fuse box complete with cutout
23	2	S. T. L. R.—224	Screw cover terminal box
24	1	H. S. C. R—22	Headlight switch
25	1	E. L. S. C.—22	Engineers' order lamp
26	1	T. F. H. C.—225	Toggle switch fitting
27	1	B. R. B. B.—23	3 wire receptacle
28	1	B. P.—30	3 wire plug for above receptacle
29	1	S. T. B.—22	Screw cover conduit fitting
30	1	M. R. A.—22	Receptacle
31	1	M. R. A.—2	Receptacle
32	2	Benjamin No. 903	Attachment plug for above receptacles
33	1	T. S. L. C.—228	Back up lamp
34	2	M. L. B. R.—20	Marker lamps
35	2	L. C. N.—40	Cab light fixture (steam and air gauges)
36	1	L. C. B.—55	Cab light fixture (water glass)
37	1	L. C. G.—7013	Cab light fixture (lubricator)
38	Length to suit	2 Cond. No. 16	Delta Beston Heater cord
39	Length to suit	2 Cond. No. 16	Reinforced cord
40	Length to suit	No. 12	Headlight wire
41	Length to suit	No. 14	Headlight wire
42	Length to suit	½ inch	Galvanized conduit
43	Length to suit	¾ inch	Galvanized conduit
44	1	G.—30	250 watt, 34 volt, med. screw base lamp
45	11	S.—17	15 watt, 34 volt, med. screw base lamp
46	1	G.—25	100 watt, 34 volt, med. screw base lamp

OLIVER ELECTRIC & MANUFACTURING COMPANY
SAINT LOUIS, U. S. A.



Adaptability

★ The wide adaptability of Bates poles makes them applicable for every pole purpose.

They readily and economically adapt themselves to fabrication into combination poles, towers, A frames and H frames—and for substation construction. As trolley supports, for signal tower use, as transformer rack frames, and as street light standards—they are used to advantage.

Get a Bates quotation for consideration and comparison!

Bates Expanded Steel Truss Co.

Illinois Merchants Bank Bldg.
CHICAGO, ILL., U. S. A.

BATES ONE PIECE EXPANDED STEEL POLES

At the Engine Terminal

View shows exterior of roundhouse, electrically operated turntable, with electric tractor and a dead engine hauling device. The small view shows interior of machine shop, with G-E Motors driving machine tools

Service—with G-E Motors

G-E Motors and Controllers are important factors in speeding up locomotives through the engine terminal shown here. Turntable, dead engine hauling device, machine shop, coaling station, ash handling equipment—all are G-E Motor-driven.

Steady, reliable power, with "finger-tip" control, saves valuable minutes—prevents costly delays—which turn many idle locomotives hours into revenue-earning time.

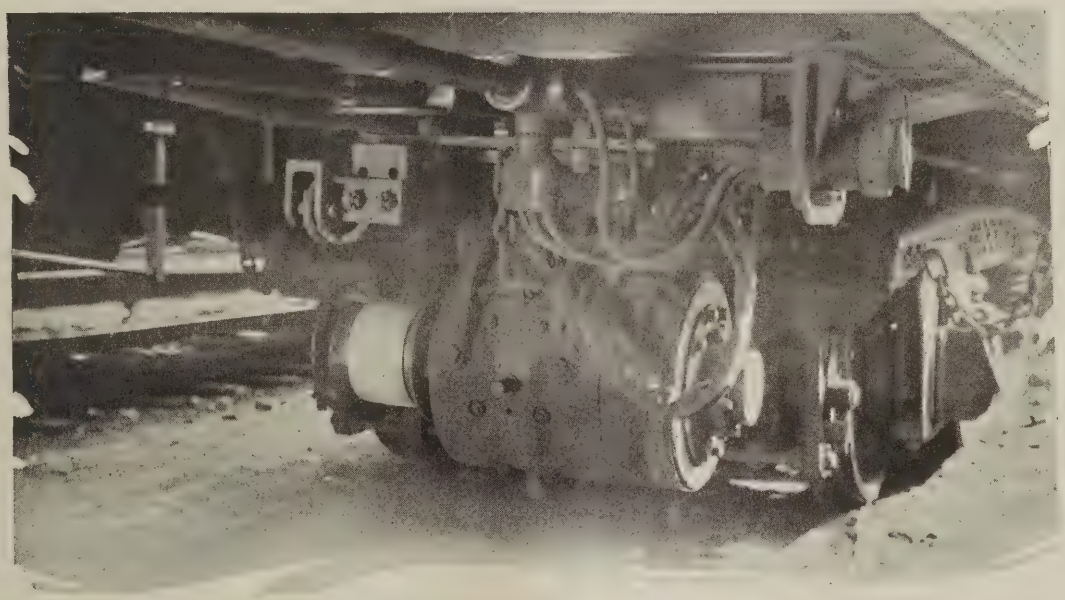
G-E engineers will gladly cooperate with you, and recommend proper electrical equipment.

General Electric Company
Schenectady, N. Y.
Sales Offices in all large cities

GENERAL ELECTRIC

238-736

SKF



Reliability In All Seasons

From Ball Bearing Car Lighting Generators

DOWN near the road-bed, exposed to flying dirt, gravel and the snows and ice of winter, this car lighting generator equipped with Hess-Bright Deep-Groove Ball Bearings responds to instant demands and furnishes unfailing current.

Such reliability is due to the wear-proof qualities of Hess-Bright Ball Bearings which safe-guard the generator from electrical troubles. Sealed housings prevent lubricant leakage and effectively exclude foreign matter from the bearings.

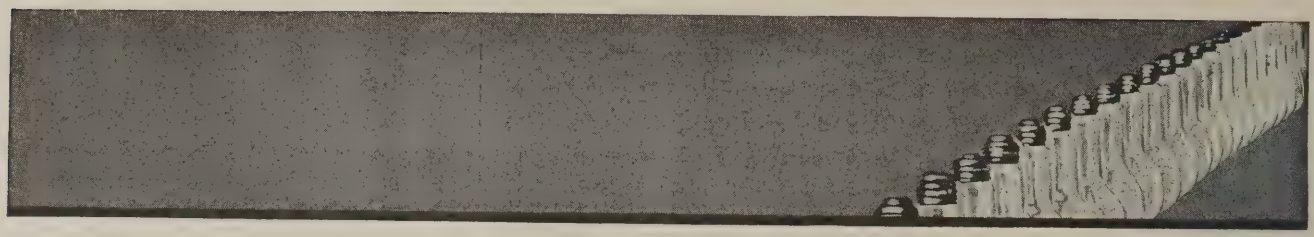
THE HESS-BRIGHT MANUFACTURING COMPANY

Supervised by SKF INDUSTRIES, INC., 165 Broadway, New York City

1284

Cross Section of Single-Row Bearing

Cross Section of Double-Row Bearing



Over 20,000,000

Over 20,000,000 Sunbeam Mazda Lamps will shine tonight

Millions of Sunbeam Mazda Lamps are doing their part the country over, in turning night into day. Such universal usage did not just happen. It is due to the high standard of service which Sunbeam Mazda Lamps are giving.

There is a Sunbeam Mazda Lamp for every railroad need—flood lighting, car lighting, locomotive cabs, head lights, station lighting and platform lighting.

There need be no vacant sockets as complete stocks of Sunbeam Mazda Lamps are maintained at our 49 Distributing Houses; at least one of which is on your lines. These Houses assure prompt deliveries. Also they offer the services of specialists on every lighting problem.

Western Electric SUNBEAM

Western Electric

OFFICES IN 49 PRINCIPAL CITIES

Insulation

The supreme importance of really efficient rubber insulation on Wires and Cables is too often overlooked.

Safety to life and limb, and long lasting service, should carry more weight than low price or any other consideration.

HAZARD Wires and Cables are *safe*. They stand up under unexpected surges in current because a high factor of safety is built into them—the compound ingredients are right, the formula is right, and the supervision and testing service are right.

For the difficult jobs we have developed special types of Cables that greatly outlast ordinary Cables. Get our special data on any of the following:

LORECA ARC WELDING CABLE. Extra flexible and wearproof. Patented.

SPIRALWEAVE PORTABLE CORD for Drills, Riveters, Portable Machinery, Etc.

HAZARD 30 per cent Para Wires & Cable for roundhouse and shop lighting and power wiring.

HAZARD Locomotive Headlight Wire, Flexible copper conductor, heat resisting insulation hermetically sealed by a two-fold covering with a smooth, hard flame-proof finish.

SPIRALWEAVE CABLE, loom woven covering for strength and wear.

PARKWAY UNDERGROUND CABLE, steel tape armored. No conduits necessary.

Quality Survives

HAZARD
RUBBER INSULATED
WIRES & CABLES

Hazard Mfg. Co.

NEW YORK
533 Canal St.

PITTSBURGH
1st Nat'l Bank Bldg.

CHICAGO
552 W. Adams St.

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1415 Wazee St.

BIRMINGHAM, 1701 First Ave

Wilkes-Barre, Pa.

ILLINOIS INSULATORS

Type No. 370 is one of the many insulators particularly adaptable to Steam Railway work.

Nominal Rating	22,000 volts
Dry Flashover	80,000 volts
Wet Flashover	50,000 volts
Leakage Distance	10 inches
Number per Barrel	65
Weight per Barrel	350 pounds
Weight per Hundred	540 pounds

Buyers of porcelain insulators and allied products should look into the products of the ILLINOIS ELECTRIC PORCELAIN COMPANY. Their long practical experience in the Electric Porcelain field and all the resources of a highly specialized organization are back of every product.

There is a type for every requirement in the railway electrical field, as, besides distribution insulators, a full line of transmission suspension, strain, transformer bushings, wall bushings, bus supports and special shapes are available.

An attractive catalogue is now available showing these various products, together with comparative catalogue data and miscellaneous information concerning porcelain products. This catalogue will be sent to you upon request.

MANUFACTURED BY

ILLINOIS ELECTRIC PORCELAIN COMPANY

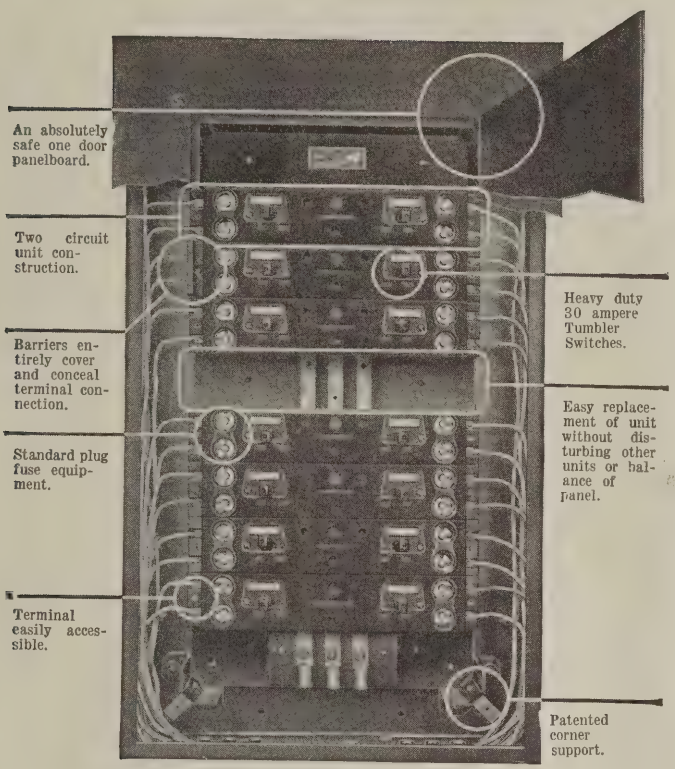
RAILWAY SALES AND SERVICE BY

F. A. Lundy Company
A NATIONAL SALES & ENGINEERING SERVICE for RAILWAYS

Union Trust Bldg., Pittsburgh, Pa.

Monadnock Bldg., Chicago, Ill.

A Capable Panelboard for Station Buildings


An absolutely safe one door panelboard.
Two circuit unit construction.
Barriers entirely cover and conceal terminal connection.
Standard plug fuse equipment.
Terminal easily accessible.
Heavy duty 30 ampere Tumbler Switches.
Easy replacement of unit without disturbing other units or balance of panel.
Patented corner support.

Blank end section covers main terminals. Plenty of room for connecting.

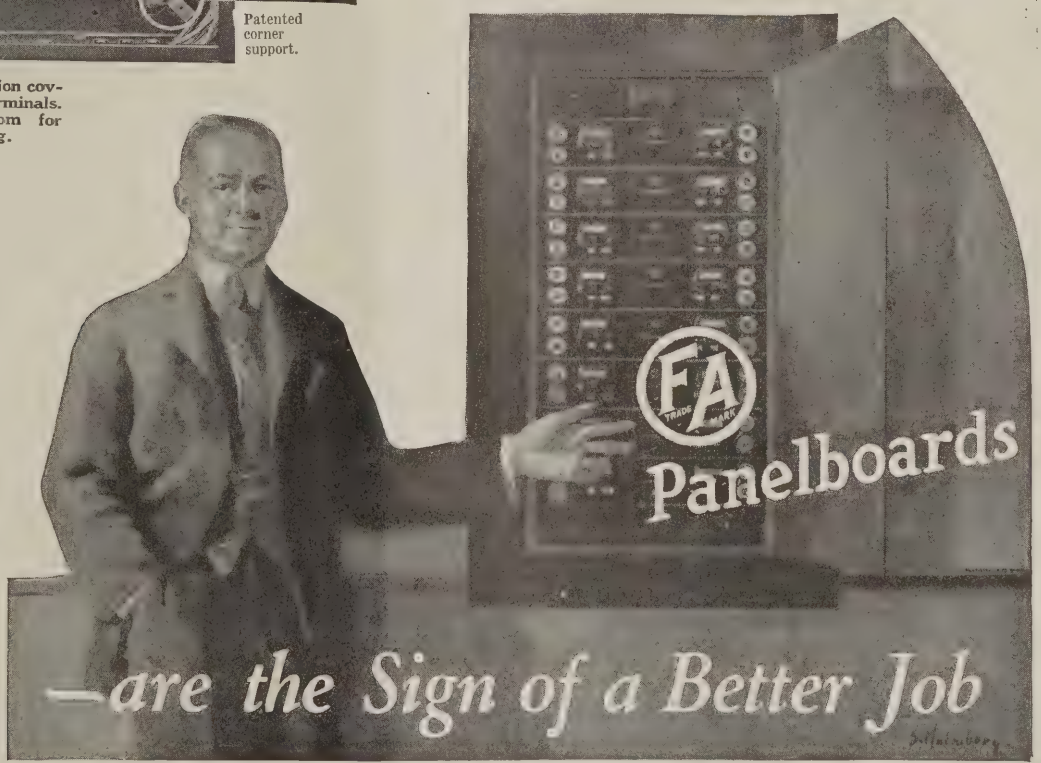
Check over what you think you ought to get in a station building panelboard and compare it point by point with this Type T-P Ⓕ Safety Type Panelboard.

Here is practical design that makes installing low in cost. Here, too, is standardization of manufacture that coordinates every part, including the steel cabinet, so that standardized practice is possible.

More important than all, here is sturdy construction that withstands years of hard use without constant "tinkering" and replacements.

Ⓕ Panelboards come completely assembled ready for wiring. Made in Plug and Cartridge fuse types. With and without controlled branches.

Send for Catalog



Frank Adam
ELECTRIC COMPANY

Detroit, Cincinnati, New Orleans, Dallas, Minneapolis, Kansas City, Denver, Indianapolis, **ST. LOUIS**, Seattle, Los Angeles, San Francisco, Chicago, Philadelphia, Pittsburgh, New York City, Winnipeg, Can.

BRANCH OFFICES

KERITE
in a half-century
of *continuous*
production,
has spun out
a record
of performance
that is
unequalled
in the history
of
insulated wires
and cables.

KERITE INSULATED WIRE & CABLE COMPANY
NEW YORK CHICAGO

Tight Contact Assured

Note the space between the cap and ferrule? That permits screwing the caps, link and washers up tight on the ferrules. It insures perfect contact and infallible performance.

The link cannot twist, as it is inserted through slots in washers that are held in position by means of dowels.

"UNION" RENEWABLE FUSES

contain more metal in the caps and ferrules than other makes. Heating of metal parts and charring of tube is thus reduced to a minimum.

Moreover, the "Union" Link blows without flash or violence, further reducing the liability of damage to tubing when fuse blows.

Every part is designed to give these fuses extra long life—to make them live up to our claim that

The "Union" Is a Good, Dependable Fuse

"Union" Renewable and Non-Renewable Fuses are sold by leading jobbers and dealers.

Interesting Catalog sent on request.

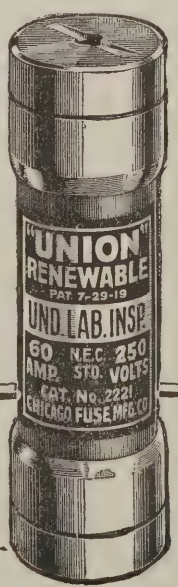
CHICAGO FUSE MFG. CO.

MANUFACTURERS OF

ELECTRICAL PROTECTING MATERIALS AND CONDUIT FITTINGS

LAFLIN & 15TH STREETS

CHICAGO



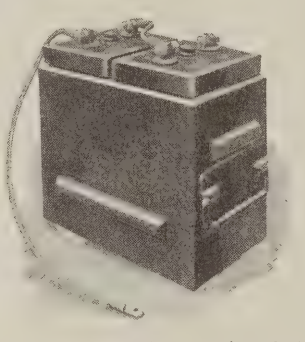
UNION

REG. U.S. PAT. OFF.

Once the "Blucher" hit 4 miles per hour

New from the shop, George Stephenson's "Blucher" walked away with "8 loaded wagons." Speed—four miles per hour in spite of a grade of 1 foot in 450!

No wonder they said the steam locomotive "had not arrived at such perfection as to have brought it into general use."



It was that way with train lighting batteries, too. In the earliest battery days they made no such records as to long life and low maintenance cost as can be shown today by Willard Batteries.

We've been building batteries for more than twenty years. And there are still a good many old-time Willard Batteries in active service. That's the result of putting the best stuff into the plates and making them a little thicker than they really have to be.

Willard Storage Battery Company
Cleveland, Ohio

Willard STORAGE BATTERY

Keystone Steel Car Lighting Pulleys

The choice of many master car builders. Provided with re-inforced hub and arms set lengthwise to strain. Will operate regardless of jolts, vibration, rain, snow or ice. Furnished with Oneida corrugated bushings for straight or tapered axles. Grips shaft firmly—requires no machining and only ¼" clearance between car axle and pulley bore.

Dodge Manufacturing Corporation
General Offices: Mishawaka, Indiana.
Works: Mishawaka, Ind., and Oneida, N. Y.

Electric Arc Welding

In Building

Recently a large concern erected a building, the framework of which was joined by electric arc welding—there were no rivets used at all.

New York building departments passed the process after stiff tests.

Electric Arc Welding

By Wanamaker and Pennington

is full of all the necessary electric welding information.

Shows what has been done and how it was done.

Up-to-date and complete.

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Gentlemen:
Kindly send on 10 days free trial your book Electric Arc Welding. At the end of that time if I keep the book I will send its price, $4.00.

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THE ROTH
Constant Potential System

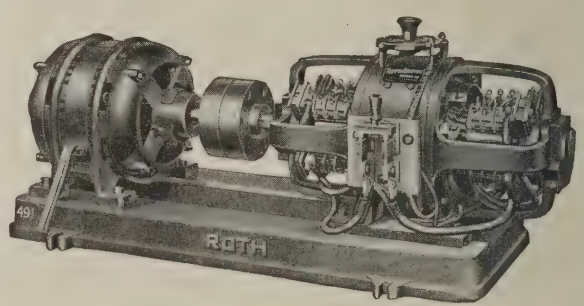
A modern and efficient method for charging storage batteries for railway signal and car lighting.

Each battery is charged independently of another.

Each battery takes just the proper amount of current that its condition warrants.

A real taper charge is given.

There is no excessive heating or gassing.



It means a better charge and a longer life for the battery.

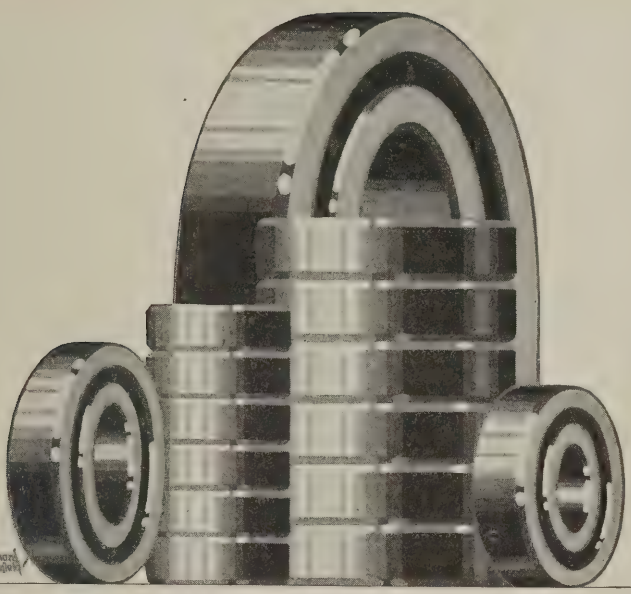
There is no current wasted thru resistance in charging rheostats.

It saves battery room labor costs.

It saves battery charging costs.

It is EFFICIENT AND ECONOMICAL.

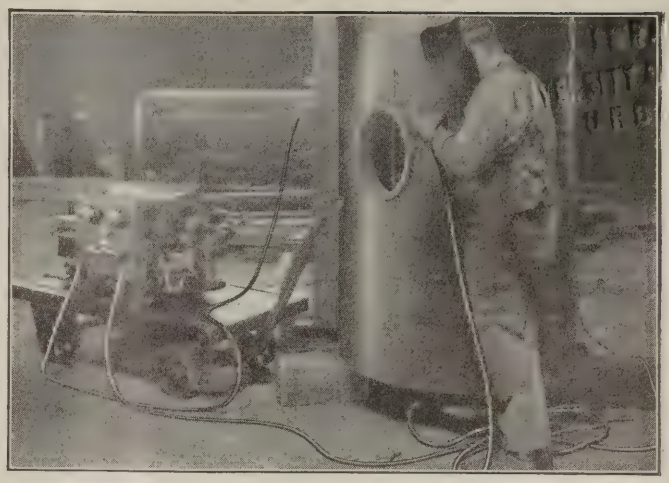
ROTH BROTHERS & CO.
1406 West Adams St. Chicago, Ill.
Distributors in all principal cities



Each Ahlberg Ground Bearing is given the same test as a new bearing before leaving our factory. This is one reason why Ahlberg Ground Bearings are superior to all other reconstructed bearings

AHLBERG BEARING COMPANY

321 East Twenty-ninth St Chicago



Burke Electric Co. standardizes on Super Service

The Burke Electric Company, manufacturer of electric welders, Erie, Pa., is one of the many firms which have standardized on Rome Special Super Service Welding Cable.

Because it has extreme flexibility, is nonkinkable, absolutely waterproof, and wears longer,—these are the reasons why Super Service is standard equipment on the Burke Arc Welders.

These machines are made in sizes ranging from 200 amperes to 2000 amperes capacity in variable voltage and constant potential types and for both portable and stationary use.

Super Service Welding Cable is especially designed to meet the exacting conditions of this work. The very fine wires used in stranding the conductor insure the utmost ease in handling and eliminate the splicing on of separate lengths for the electrode holder. The tough waterproof rubber wall protects the operator from shocks in wet or damp weather and assures longer wear and uninterrupted service.

ROME WIRE CO. *Mills and Offices* ROME, N. Y.

Diamond Mills: BUFFALO, N. Y.

BRANCHES:
NEW YORK 50 Church St. BOSTON Little Bldg. DETROIT 25 Parsons St. CHICAGO 14 E. Jackson Blvd.
LOS ANGELES, J. G. Pomeroy, 336 Azusa Street
CLEVELAND, 1200 West Ninth Street

ROME WIRE

WIRE-ROME

YAGER'S

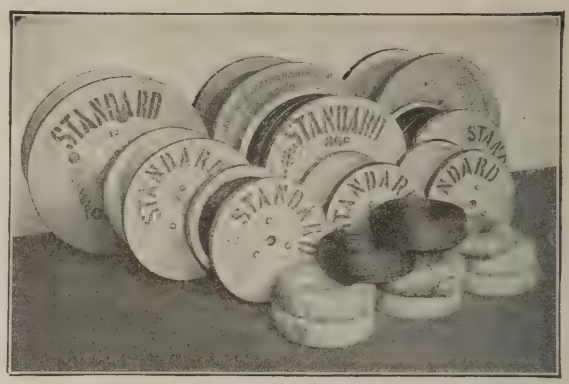
TRADE-MARK REG.

Soldering Salts

Are economical; Safe at all times;
Your Guarantee of Satisfaction.
½ lb., 1 lb., 5 lb. Enameled Cans.

ALEX. R. BENSON CO., Inc.
HUDSON NEW YORK

For list of distributors see McRae's 1924 Blue Book.



STANDARD
Wires and Cables

meet every requirement of those discriminating buyers who demand the highest quality of workmanship and material at a fair price.

Among these, the largest buyers in the country, we find our permanent and loyal customers.

If you are interested in dependable, durable wire, write our nearest office for catalogues and prices.

STANDARD UNDERGROUND CABLE COMPANY

BOSTON WASHINGTON CHICAGO KANSAS CITY
NEW YORK ATLANTA DETROIT LOS ANGELES
PHILADELPHIA PITTSBURGH ST. LOUIS SEATTLE
SAN FRANCISCO

For Canada: Standard Underground Cable Co., of Canada, Limited, Hamilton, Ont.

Have Your Electrical Controlling Mechanisms Interchangeable Units as in the case of I-C made in two parts?

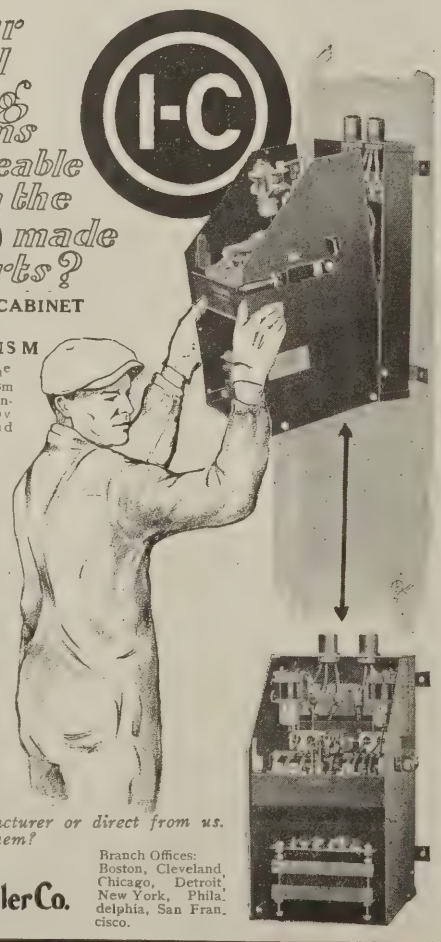
THE ENCLOSING CABINET AND THE MECHANISM

By taking out two screws it the entire compensator mechanism can be removed from the conduit section, leaving it empty for the running of wires and connecting of conduit. Knockouts at top and bottom. Isn't that an easy way to install a compensator?

Also, the mechanism cases and the conduit sections are interchangeable. You can take down one compensator and put up another without disturbing a conduit connection. Any rating, from 7½ to 50 hp. at 440 volts A larger size, from 60 to 100 hp. When you take down the case and remove the covers, every contact and connection is in plain view and easily accessible. Maintenance costs are greatly reduced.

This same construction is used for both automatic and manually operated compensators, also for automatic starters.

You can buy I C compensators from any electric motor manufacturer or direct from us. Why not insist on them?



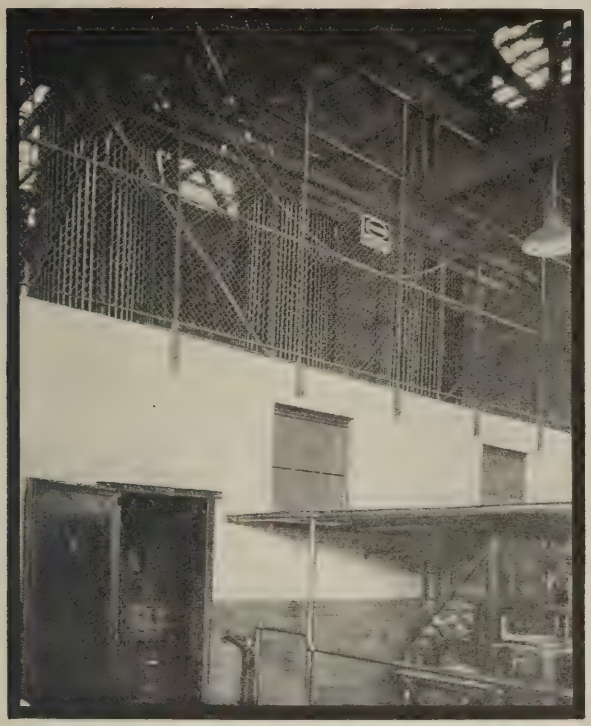
Industrial Controller Co.
Milwaukee, Wisconsin

Branch Offices: Boston, Cleveland, Chicago, Detroit, New York, Philadelphia, San Francisco.

When renewing your burned out headlight equipment coils, insist upon receiving W E finish Salamander Asbestos Insulated Magnet Wire. It has an oil proof and acid proof finish and will keep your generator sets on the road.

YORK INSULATED WIRE WORKS
of General Electric Co.

Works: York, Pa. 1737 Broadway, N. Y. City



Kuhlman Transformer Installation at Detroit Copper and Brass Rolling Mills, handling wire and rod mills. Mr. G. S. VAN NORMAN, Electrical Engineer.

Kuhlman Transformers are backed by Eager Service

The Kuhlman Electric Company has manufactured transformers only since 1893. Through these years of experience we have found that one of the most appreciated factors in our relations with customers is the prompt service that we give.

Our energies are directed to two things.

(1) Building a mighty good transformer quickly, and

(2) Taking care of your service needs within 24 to 48 hours, should you call on us.

ASK FOR BULLETIN 610

KUHLMAN ELECTRIC COMPANY

Manufacturers of Power, Power Distribution and Street Lighting Transformers

BAY CITY, MICHIGAN

KUHLMAN TRANSFORMERS

TRADE

ANDERSON

MARK

For Platform and Station Lighting

No need to keep a man at the station at night to turn the lights on and off when an Anderson Time Switch will do it for you—never making a mistake, nor ever forgetting.

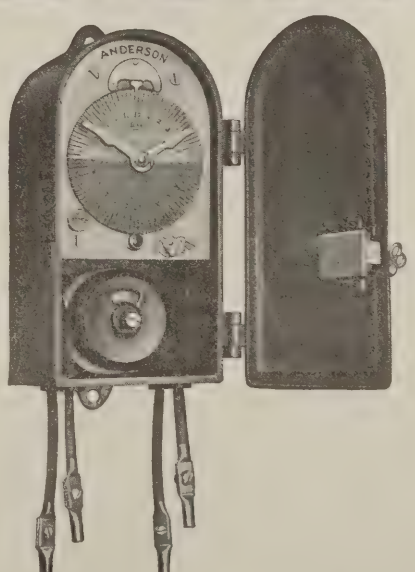
You simply set the switch at the predetermined times at which you want the lights to go on and off; thereafter the dependable Anderson Time Switch will do its work accurately and faithfully, night after night, with no more attention than a weekly winding.

Bulletin No. 37 describes and illustrates different types of Time Switches for various conditions of service. Send for your copy now.

Albert & J. M. Anderson Manufacturing Co.

289-305 A. Street, Boston, Mass.

New York—135 Broadway
Philadelphia—429 Real Estate Trust Building.
Chicago—105 S. Dearborn St.
London, E. C. 2, 12 Moor Lane



Type P. Time Switch
5 amp., 250 and 600 v.
10 amp., 125 and 250 v.

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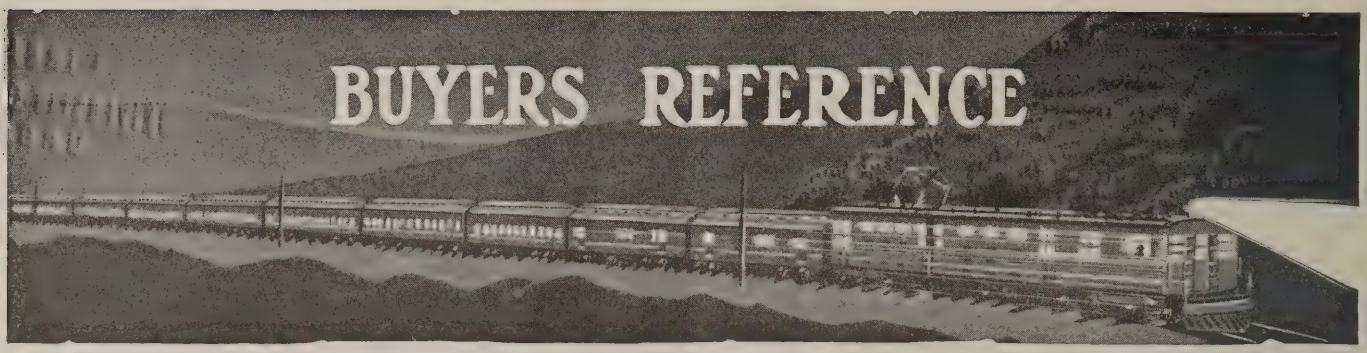

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General Electric Co.
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Goodrich Rubber Co., B. F.

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Brushes, Car Lighting, Generator
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Buffers
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Hazard Mfg. Co.
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Standard Underground Cable Co.
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General Electric Co.
Goodrich Rubber Co., B. F.
Hazard Mfg. Co.
Kerite Insulated Wire & Cable Co.
Rome Wire Company.
Standard Underground Cable Co.
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Car Lighting Equipment
Oliver Electric & Mfg. Co.
Safety Car Heating and Lighting Co.

Circuit Breakers, Carbon
General Electric Co.

Circuit Breakers, Oil
Westinghouse Electric & Mfg. Co.

Clamps and Connectors
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Compensators, Automatic
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Compensators, Manual
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Conduit Fittings
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Electric Controller & Mfg. Co.

Control Apparatus, Car Lighting
Industrial Controller Co.
Safety Car Heating and Lighting Co., The
Westinghouse Electric & Mfg. Co.

Controllers, Automatic
Electric Controller & Mfg. Co.
Industrial Controller Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Controllers, Crane
Electric Controller & Mfg. Co.
General Electric Co.

Controllers, Manual
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.

Controllers, Machine Tool
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.

Copper Rods and Tubes
Standard Underground Cable Co.

Cutouts, Entrance
Chicago Fuse Mfg. Co.

Electrical Apparatus and Supplies
Bryant Electric Co., The
General Electric Co.
Westinghouse Electric & Mfg. Co.

Electrification Construction Materials
General Electric Co.
Westinghouse Electric & Mfg. Co.

Electrification of Steam Roads
General Electric Co.
Westinghouse Electric & Mfg. Co.

Fans, Car
General Electric Co.
Safety Car Heating and Lighting Co., The
Westinghouse Electric & Mfg. Co.

Fans, Desk and Bracket
General Electric Co.
Westinghouse Electric & Mfg. Co.

Fixtures, Car Lighting
Oliver Elec. & Mfg. Co.
Safety Car Heating and Lighting Co., The

Fixtures, Locomotive Cab Lighting
Oliver Electric & Mfg. Co.

Fixtures, Office, Shop and Yard Lighting
Oliver Elec. & Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Floodlights
General Electric Co.
National Lamp Works of General Electric Co.

Flux, Soldering
Benson Co., Alex. R.

Fuses, Cartridge
Chicago Fuse Mfg. Co.
General Electric Co.

Fuses, Plug
Chicago Fuse Mfg. Co.

Fuses, Refillable
Chicago Fuse Mfg. Co.
General Electric Co.

Generators, Axle Driven
Safety Car Heating and Lighting Co., The

Generators, Car Lighting
Safety Car Heating and Lighting Co., The

Generators, Power and Lighting
General Electric Co.
Roth Brothers Co.
Westinghouse Electric & Mfg. Co.

Headlight Reflectors and Cases
General Electric Co.
Sunbeam Electric Mfg. Co.

Headlight Turbo Generators
General Electric Co.
Sunbeam Electric Mfg. Co.

Headlights, Locomotive
Sunbeam Electric Mfg. Co.

Hose
Goodrich Rubber Co., B. F.

Insulating Compounds
General Electric Co.
Standard Underground Cable Co.
Westinghouse Electric & Mfg. Co.

Insulating Materials
General Electric Co.
Westinghouse Electric & Mfg. Co.

Insulators
Illinois Electric Porcelain Co.

Jars, Battery
Goodrich Rubber Co., B. F.
Safety Car Heating and Lighting Co., The

Lamps, Gauge
Oliver Electric & Mfg. Co.

Lamps, Incandescent
National Lamp Works of General Electric Co.
Western Electric Co.
Westinghouse Electric & Mfg. Co.

Lighting Units, Indoor and Outdoor
Westinghouse Elec. & Mfg. Co.

Lifting Magnets
Electric Controller & Mfg. Co.

Line Material
General Electric Co.
Westinghouse Electric & Mfg. Co.

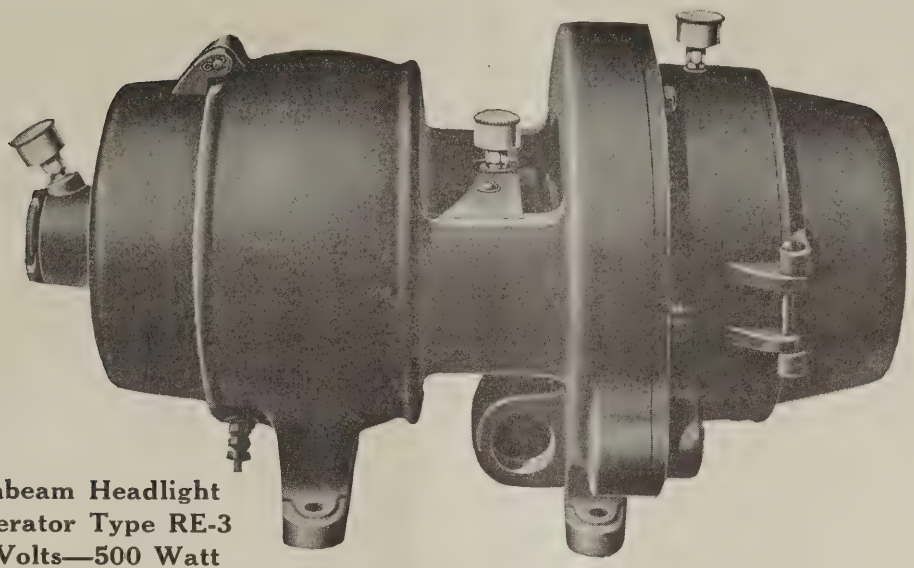
Locomotives, Electric
General Electric Co.
Westinghouse Electric & Mfg. Co.

Mechanical Rubber Goods.
Goodrich Rubber Co., B. F.

Motors, A. C.
Electric Controller & Mfg. Co.
General Electric Co.
Howell Electric Motors Co.
Roth Brothers & Co.
Westinghouse Electric & Mfg. Co.

Motors, D. C.
Electric Controller & Mfg. Co.
General Electric Co.
Howell Electric Motors Co.
Roth Brothers & Co.
Westinghouse Electric & Mfg. Co.

Motor Generator Sets
Electric Controller & Mfg. Co.
General Electric Co.
Roth Brothers & Co.
Westinghouse Electric & Mfg. Co.



Sunbeam Headlight Generator Type RE-3 32 Volts—500 Watt

Uniform voltage depends upon close regulation

Why is the Sunbeam Turbo-Generator Type RE-3 noted for uniformity of voltage day in, day out, under the most exacting conditions of service? Because—

(a) The brush contact is perfect.

(b) The commutator is suspended between two ball-bearings so that perfect alignment is maintained. "Wobbling" is impossible.

(c) Set the governor and it stays set. The whole governing mechanism operates in the atmosphere. Proper lubrication is possible because there is no live steam to "cut" the oil.

(d) The valve, which is controlled by the governing mechanism is so reliable and responsive that it adjusts itself instantly to every change of load or steam pressure.

This is the close regulation that distinguishes the Sunbeam. It provides an unvarying flow of current; lengthens the life of lamps; saves the maintainer's time; conserves steam; prevents failures.

You can't know until you use a Sunbeam Type RE-3 how efficient and free from trouble the service of a turbo-generator can be.

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Evansville, Indiana

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SUNBEAM TURBO GENERATOR

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General Electric Co.

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Anderson Mfg. Co., A. & J. M.
Electric Controller & Mfg. Co.
Industrial Controller Co.
Westinghouse Electric & Mfg. Co.

Panel Boards
Adam Electric Co., Frank.
Chicago Fuse & Mfg. Co.
Westinghouse Electric & Mfg. Co.

Panel Board Fittings
Chicago Fuse Mfg. Co.

Plugs and Receptacles, Arc Welding
Anderson Mfg. Co., A. & J. M.

Plugs and Receptacles, Battery Charging
Anderson Mfg. Co., A. & J. M.
Oliver Electric & Mfg. Co.

Plugs and Receptacles, Polyphase and Multiple
Anderson Mfg. Co., Albert & J. M.
Oliver Electric & Mfg. Co.

Pole Accessories
Bates Expanded Steel Truss Co.

Poles, Steel
Bates Expanded Steel Truss Co.

Potheads
Standard Underground Cable Co.

Rectifiers
General Electric Co.
Westinghouse Electric & Mfg. Co.

Reflectors
Safety Car Heating and Lighting Co., The
Westinghouse Electric & Mfg. Co.

Reflectors, Car Lighting
Safety Car Heating and Lighting Co., The

Regulators, Car Lighting
Safety Car Heating and Lighting Co., The

Regulators, Generator
Safety Car Heating and Lighting Co., The

Regulators, Lamp
Safety Car Heating and Lighting Co., The

Repair Parts, Axle Lighting Equipment
General Electric Co.
Oliver Electric & Mfg. Co.
Safety Car Heating and Lighting Co., The

Repair Parts, Electric Headlight
Oliver Electric Mfg. Co.
Sunbeam Electric Mfg. Co.

Rheostats, Field
General Electric Co.

Rubber Jars
Goodrich Rubber Co., B. F.
Safety Car Heating and Lighting Co., The

Sockets and Receptacles, Lamp
Bryant Electric Co., The
Central Electric Co.
Westinghouse Electric & Mfg. Co.

Soldering Compounds
Benson Co., Alex. R.

Stops, Electric Limit
Electric Controller & Mfg. Co.

Storage Batteries
Safety Car Heating and Lighting Co., The

Switchboards
General Electric Co.
Westinghouse Electric & Mfg. Co.

Switchboard Fittings
Chicago Fuse Mfg. Co.

Switch Boxes
Chicago Fuse Mfg. Co.
Electric Controller & Mfg. Co.

Switches, Enclosed (Safety)
General Electric Co.
Westinghouse Electric & Mfg. Co.

Switches, Knife
Chicago Fuse Mfg. Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Switches, Remote Control
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Western Electric Co.
Westinghouse Electric & Mfg. Co.

Switches, Snap, Push and Pendant
Bryant Electric Co., The

Switches, Time
Anderson Mfg. Co., Albert & J. M.

Tape
General Electric Co.
Westinghouse Electric & Mfg. Co.

Towers, Steel
Bates Expanded Steel Truss Co.

Transformers, Electric Furnace
Kuhlman Electric Co.

Transformers, Instrument
Westinghouse Electric & Mfg. Co.

Transformers, Power and Lighting
General Electric Co.
Kuhlman Electric Co.
Westinghouse Electric & Mfg. Co.

Transformers, Special
Kuhlman Electric Co.

Transformers, Street Lighting
Kuhlman Electric Co.

Transformers, Welding
Kuhlman Electric Co.

Transmission Line Material
Bates Expanded Steel Truss Co.
Kuhlman Electric Co.

Wire, Asbestos Covered
York Insulated Wire Works of General Electric Co.

Wire, Bare Copper
Bryant Electric Co., The
Rome Wire Company
Standard Underground Cable Co.

Wire, Copper Clad Steel
Standard Underground Cable Co.

Wire, Insulated
Bryant Electric Co., The
General Electric Co.
Goodrich Rubber Co., B. F.
Hazard Mfg. Co.
Kerite Insulated Wire & Cable Co.
Rome Wire Company.
Standard Underground Cable Co.
York Insulated Wire Wks. of General Electric Co.

Wire, Magnet
York Insulated Wire Wks.

Wire, Telephone and Telegraph
Hazard Mfg. Co.
Kerite Insulated Wire & Cable Co.
Rome Wire Company.
Standard Underground Cable Co.

Wire, Trolley
Rome Wire Company.
Standard Underground Cable Co.

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Either battery or generator trouble, and at the first warning on the lighting-equipment inspection card the car is spotted for the side-track for complete inspection and repair.

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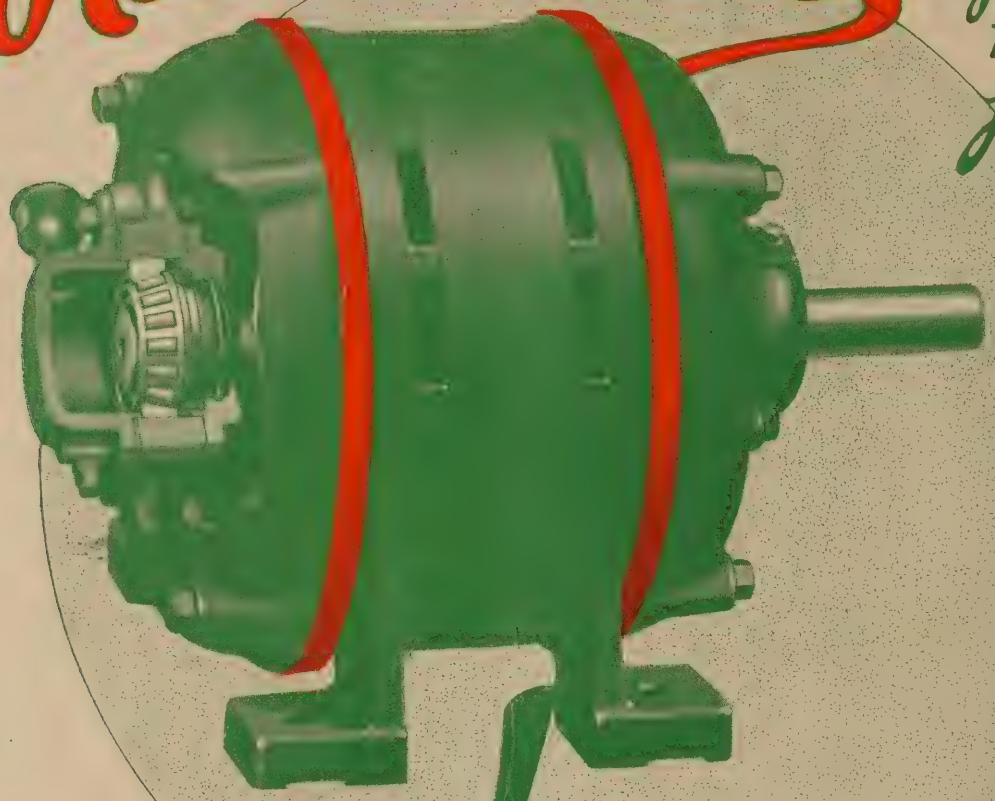

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